

Geodiversity of Africa 5 octobre 2022

Geodiversity of Morocco kingdom

Case of Tata province to establish an aspiring UNESCO Global Geopark project
(Western Anti-Atlas, Northern West African Craton)

Sanae BERRED

First vice president of Tata geopark association

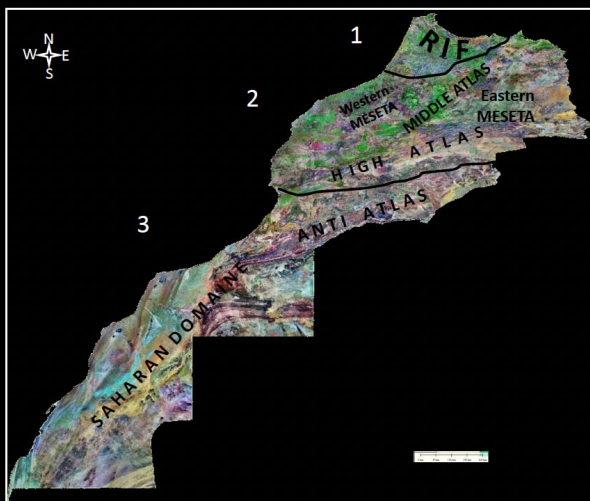
Gmail: berredsanae@gmail.com

Geographic situation of Morocco



Structural domains of Morocco

Satellite image of Morocco



Structural zones

1-Rif

2-Meseto-Atlas

3-Anti-Atlas and Saharan borders

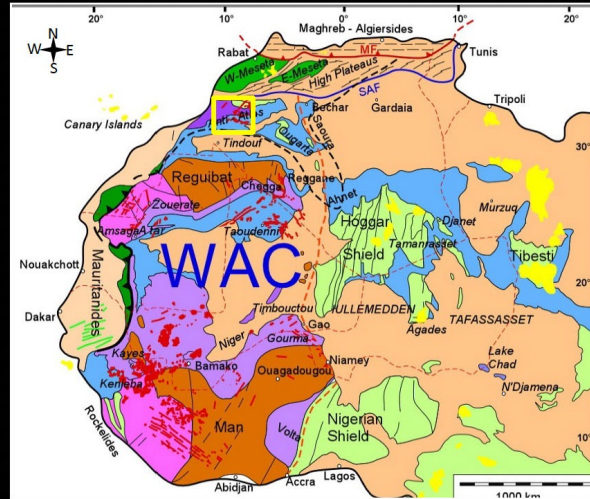
Geodiversity of Morocco

Aoulad-Sidi-Mhend et al. 2019;
 Arrad et al. 2018, 2020 ;
 Baadi et al. 2020 ;
 Beraaouz et al. 2019;
 Berred et al. 2016, 2019a, 2019b,
 2020a, 2020b, 2021, 2022 ;
 Bouzekraoui et al. 2017, 2018 ;
 DeWaele et al. 2009;
 Druguet et al. 2015;
 El Hadi et al. 2011, 2012, 2014, 2015 ;
 El Hassani et al. 2017;
 ElWartiti et al. 2009, 2017;
 Enniouar et al. 2013, 2015;
 Errami et al. 2013, 2015a, 2015b;
 Khoukhouchi et al. 2018;

Kourais et al. 2019 ;
 Lahmidi 2020, 2021, 2022 ;
 Malaki 2006;
 Mehdioui et al. 2020 ;
 Nahraoui et al. 2011; Nahraoui 2016;
 Noubhani 2015;
 Oukassou et al. 2019 ;
 Saddiqi et al. 2015;
 Salhi 2020
 Tahiri et al. 2010a ;

Geographic situation of Tata province

DEM map of the Anti-Atlas chain



Geographic characteristics

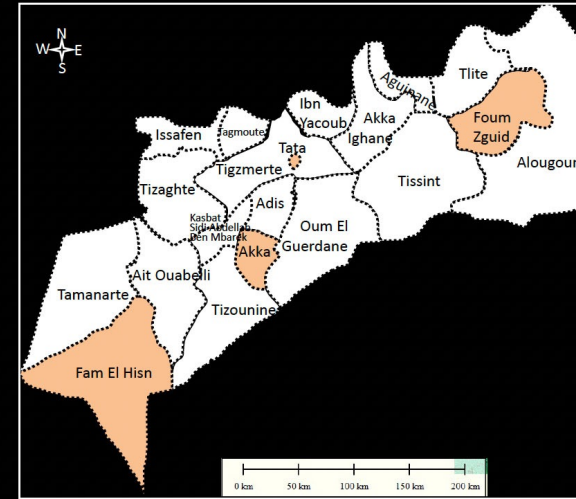
Study area :

Ouest african craton

Anti-Atlas chain

Geographic situation of Tata province

Administrative map of Tata province



Geographic characteristics

Limits: Tata province

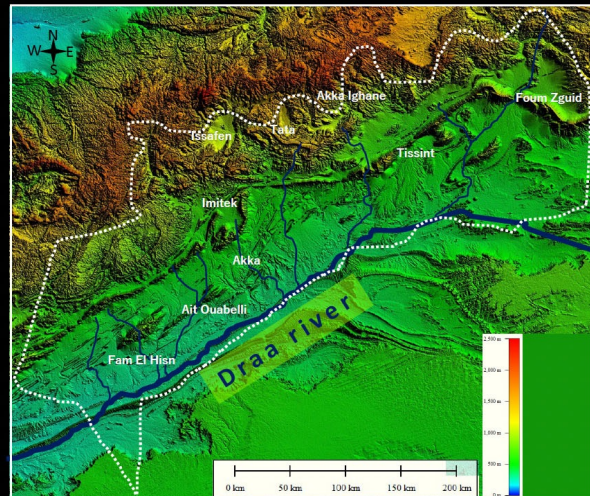
Number of municipalities: 20

Surface area: 24,000 km²

Population: 117,841

Geographic situation of Tata province

DEM map of the Tata province



Hydro-climatic characteristics

Continental Saharan climate, semi-arid with Atlantic and sub-Saharan influences

Temperature varies between 49° during the summer season and 12° in winter

Tributaries of the right bank of the Lower Draa watershed: Fom Zguid river, Tissint river, Akka Ighane river, Tata river, Akka river, Ait Ouabelli river, Fam El Hisn river, Tamanart river

Partly responsible for the morphology of the region

Why Tata province ?

Problematic

- Tata province is a region rich in natural potential
- Despite this, its heritage is unknown and its riches are unusable
- Pathetic tourist activity

Objective

General

Promotion of heritage wealth

Specific

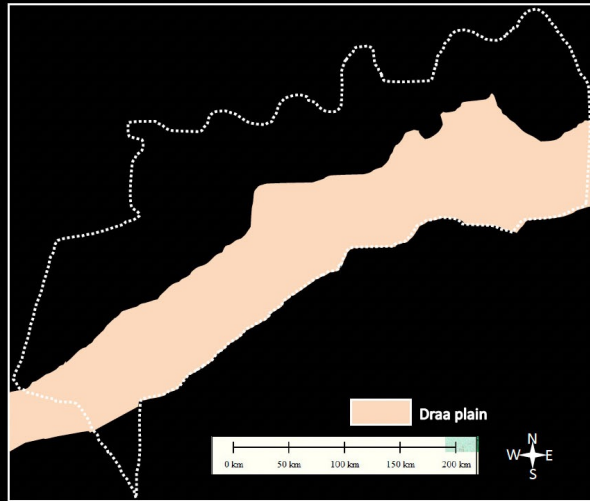
Geodiversity

Methodology

- Identification of potential sites
- Field assessment
- Selection and characterization

Geomorphological setting of Tata province

Simplified geomorphological map



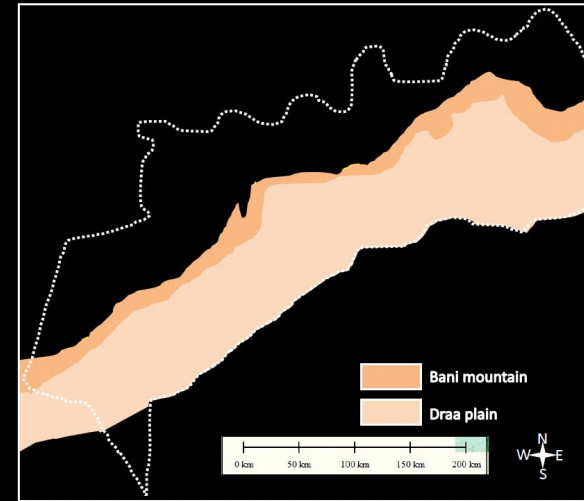
Geomorphological zones

Draa plain and Rich hills



Geomorphological setting of Tata province

Simplified geomorphological map



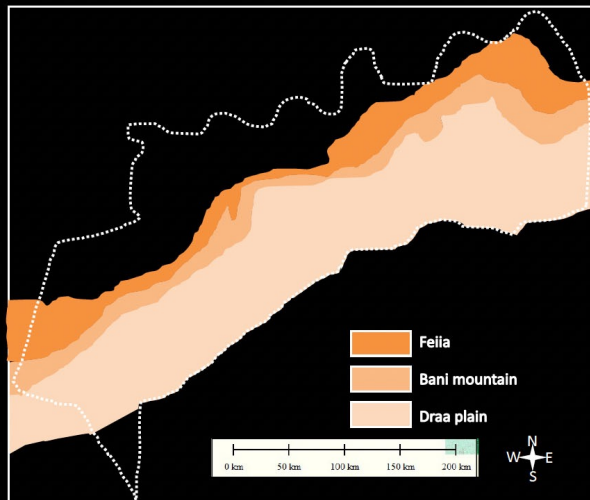
Geomorphological zones

Bani mountain in Akka area



Geomorphological setting of Tata province

Simplified geomorphological map



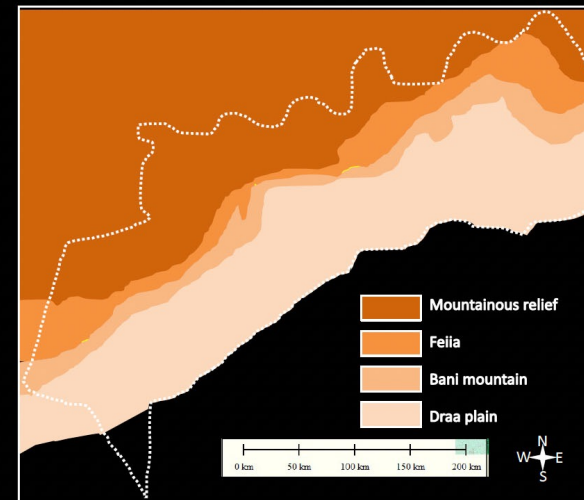
Geomorphological zones

Satellite image of Akka area



Geomorphological setting of Tata province

Simplified geomorphological map



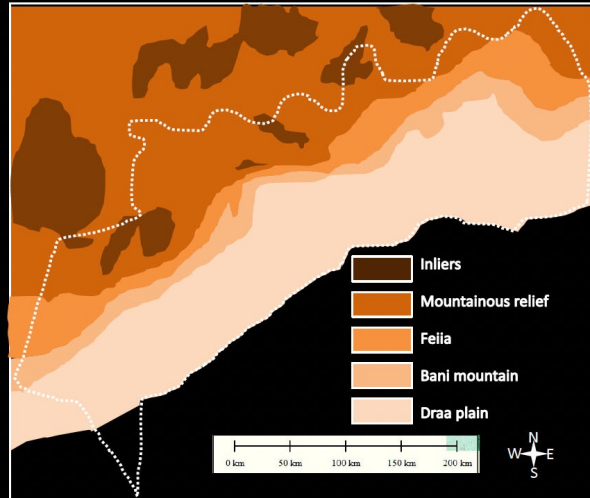
Geomorphological zones

Mountainous relief zone



Geomorphological setting of Tata province

Simplified geomorphological map



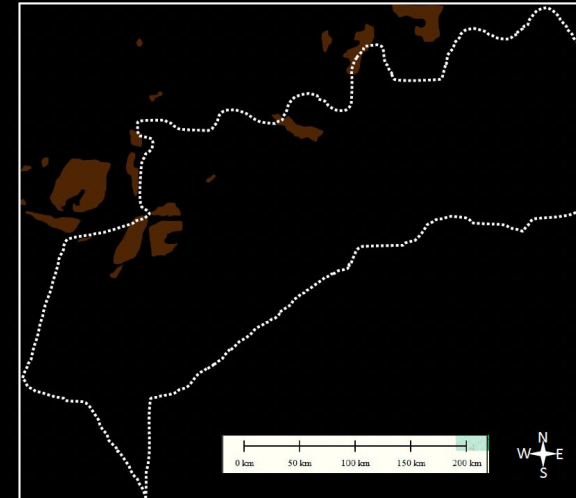
Geomorphological zones

Tagragra of Akka inlier view from the west



Geological setting of Tata province

Simplified geological map



Major tectonic events

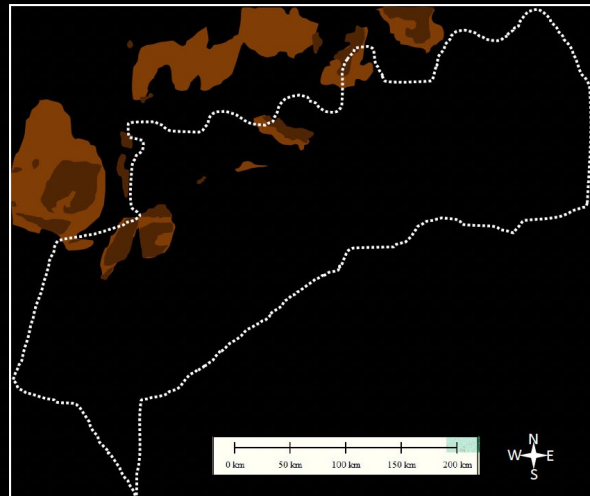
Eburnean orogeny

- D1: N-S direction: Schistosity more or less parallel to stratification;
- D2: NE-SW direction: foliation, E-W direction dextral shear and slightly plunging mineral lineations towards the SSW;
- D3: folding associated with shear and compression movements.

(N. ENNIH 2001)

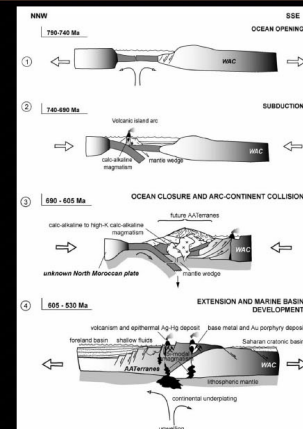
Geological setting of Tata province

Simplified geological map



Major tectonic events

Panafrican orogeny



Bou Azzer ophiolites + Siroua massif

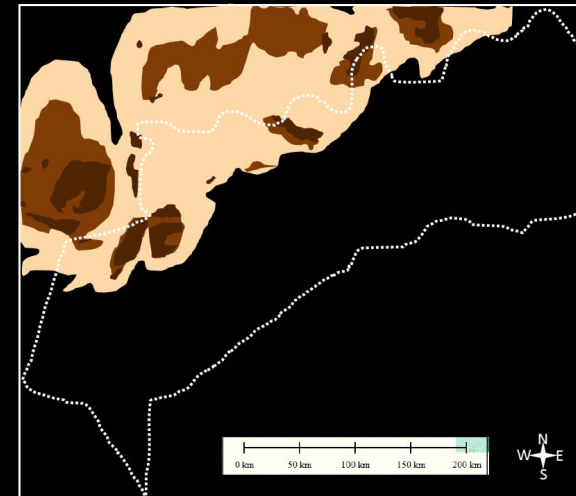
Calc-alkaline magmatism

Tangential tectonics+intrusion

Intermediate to acid magmatism

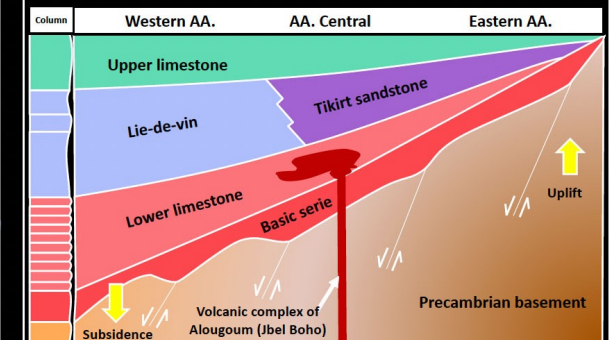
Geological setting of Tata province

Simplified geological map



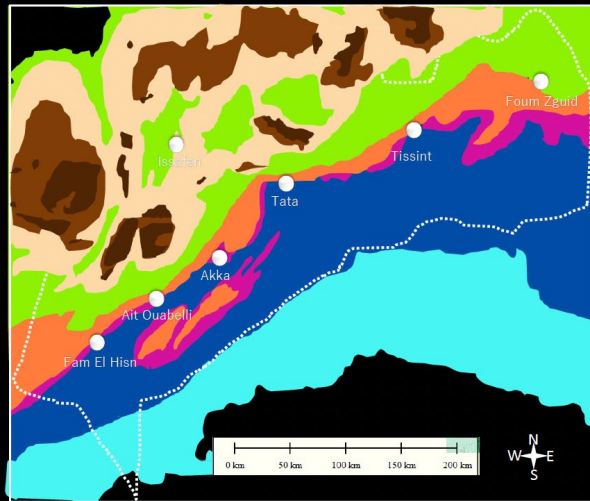
Major tectonic events

Early proterozoic extension



Geological setting of Tata province

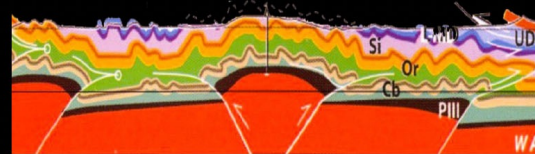
Simplified geological map



Major tectonic events

Variscan orogeny

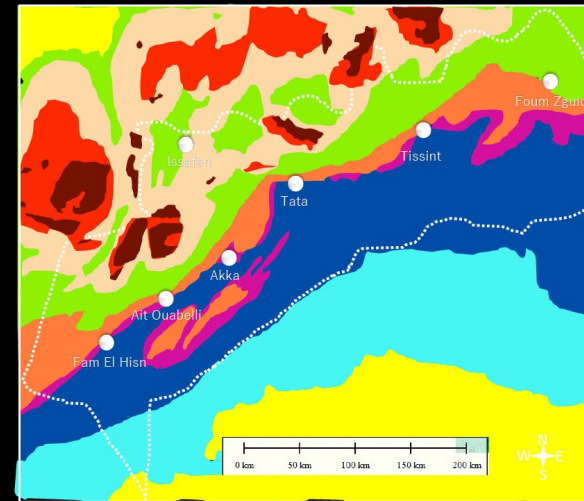
- Shortening of the very heterogeneous Hercynian orogeny
- Characterized by an influence of the blocks of the Precambrian basement
- Varied pleating style from area to area



Burkhard, 2006

Geological setting of Tata province

Simplified geological map



Major tectonic events

Alpine orogeny

- Atlasic orogenic phase and dismantling then flattening;
- Uplift during the Atlas uplift;
- Uplift during the Alpine orogeny;
- Plio-Quaternary volcanism.

Identified geodiversity sites

Geomorphological sites

Sedimentological sites

Structural sites

Karstic sites

Magmatic sites

Fluvial sites

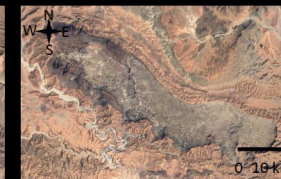
Climatic sites

Structural sites

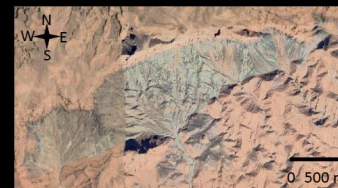
Inliers



Agouliz inlier



Tata inlier



Tanmrouit inlier



Aigo inlier



Akka inlier

(Berred S. et al. In progress)

Structural sites

Folds



Tata's oostrea

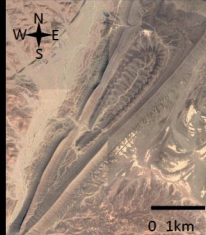


Perched syncline 1

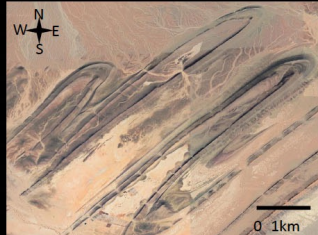


Desert mermaid

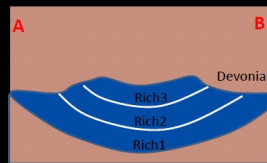
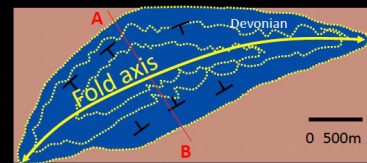
(Berred S. et al. In progress)



Akka's filaria



Perched syncline 2

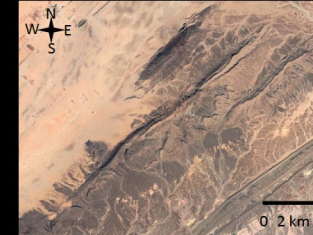


Structural sites

Folds



Mrimima



Addana



Tamanart

(Berred S. et al. In progress)

Structural sites

Folds



Icht fold



Tlit fold



Igmir fold



Asymmetrical folds



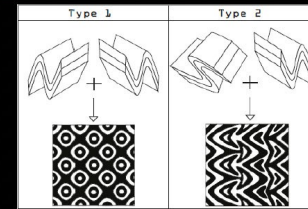
Fam El Hisn symmetrical fold



Tagmoute box fold

Structural sites

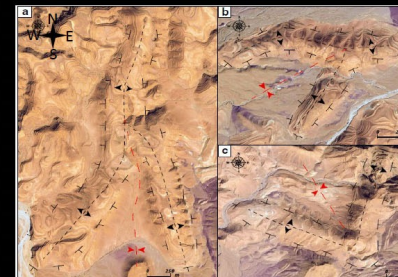
Interference folds



Ramsay and Huber (1987)



Tazoult dome and basin



Agouliz boomerangs



Agouliz mushroom



Issafen's mushroom

Structural sites

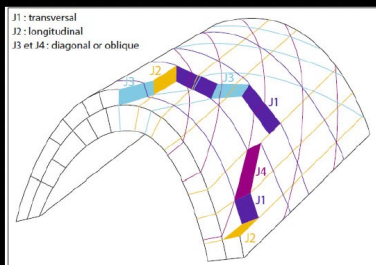
Faults



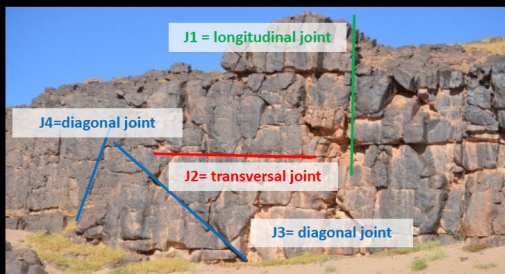
Reverse fault of Bani mountain



Tlit fold-fault



Joints related to folds



Akka-Tata joints bar



Tension fractures

Geomorphological sites

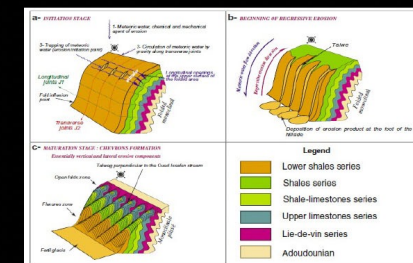
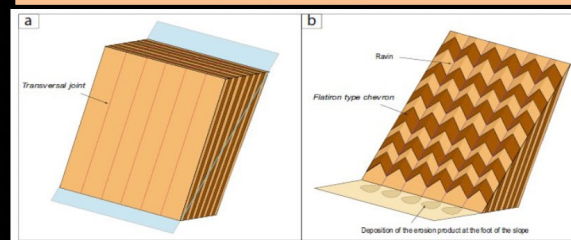
Chevrons



Issafen flat-iron



Issafen chevrons style



Geomorphological sites

Hearts



Akka hearts



Tagmoute hearts



Addana hearts

Geomorphological sites

Pyramids



Tadakoust pyramids



Tagmoute pyramid



Alougoum pyramid

Geomorphological sites

Water gaps



Foug Zguid



Foug Ait Ouabelli



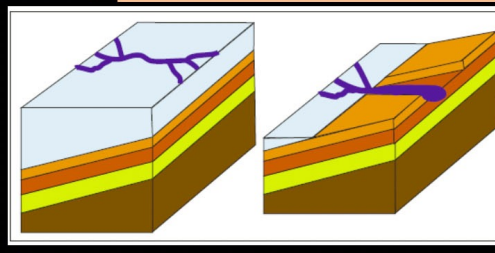
Fam El Hisn



Foug Tissint



Foug Akka



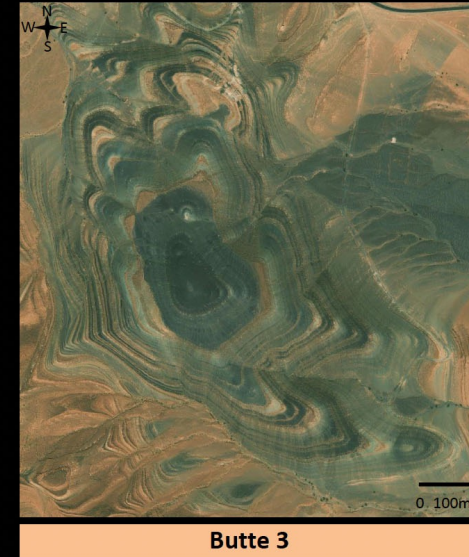
Morphogenesis of water gaps

Geomorphological sites

Buttes



Butte 1

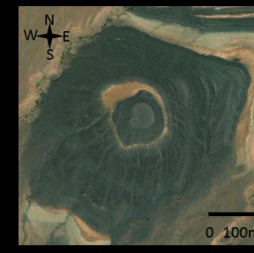


Butte 3

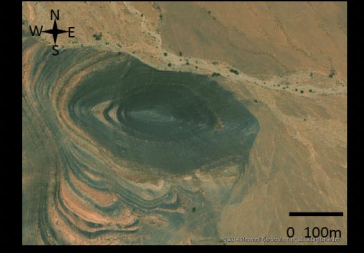
(Berred S. et al. In progress)



Butte 4



Butte 2



Butte 5

Geomorphological sites

Mesa



Foug Zguid mesa 1



Foug Zguid mesa 2

Fluvial sites

Gorges



Tamanart gorge



Agouliz



Tamzart gorge



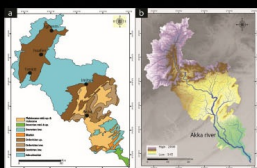
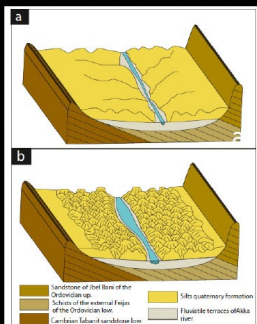
Tagmoute gorge



Targant gorge

Fluvial sites

Badlands



Akka basin



(Berred S. et al. 2019)

Akka badlands

Sedimentological sites

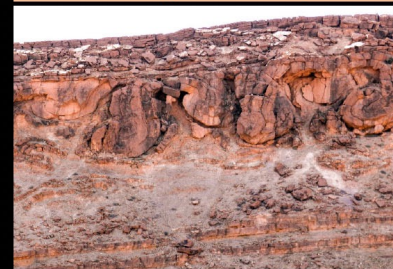
Synsedimentary structures



Alougoum slump



Issafen ball and pillow



Talat seismites



Tadakoust synsedimentary fault

Karstic sites

Karsts



Imitek karsts



Missalite cave



Tamzrart petrified waterfall

Magmatic sites

Dykes



Fom Zguid Jurassic dyke



Fom Zguid Jurassic dyke satellite image

Climatic sites

Spheroidal



Addana onion peels

Questions ?

What we can do with this geological heritage ?

How can it be used for the benefit of the local population in a sustainable way ?

How can we make the general public aware of its value ?

Answers

Geopark project

Geotourisme activity

GEOCONSERVATION

Tata aspiring geopark project

A Geopark works as a **partnership between indigenous managers and specialists in promoting earthly heritage** through education and sustainable tourism.

Management Committee

Elected institution that includes civil society activities and scientific skills

Responsible for the day-to-day management of the administrative and field affairs of the Geopark.

Steering committee

Chaired by the governor, composed of the representative of the elected councils, the representative of the partner universities and the heads of the administrative departments concerned.

Responsible for developing and defining general guidelines for the Geopark.

Scientific Committee

The scientific committee is made up of local experts and university scientists who are local partners who support the Park in the expertise of the Geopark.

Will oversee the scientific aspect of the geopark.

Tata aspiring geopark project

Natural heritage



Tata aspiring geopark project

Cultural heritage

More than 170 sites of rock art



Tata aspiring geopark project

Cultural heritage



Tata aspiring geopark project

Cultural heritage

Watchtowers



Minarets



Attics



Mosques



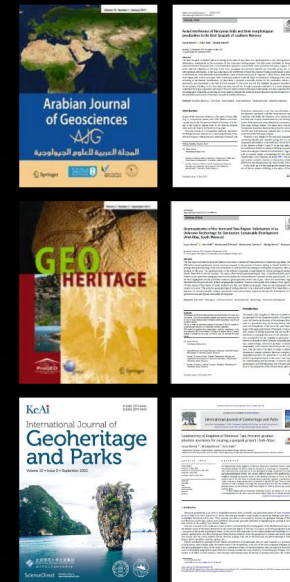
Zaouias



Msids



Tata aspiring geopark project



-**Sanae BERRED**, Khadija BERRED, Driss FADLI, (2022). Geodiversity of Kingdom of Morocco: Tata Province geomorphosites inventory for creating a geopark project (Anti-Atlas). *International Journal of Geoheritage and Parks*, Volume 10, Issue 3, Pages 367-382, ISSN 2577-4441, <https://doi.org/10.1016/j.ijgeop.2022.07.001>.

- **Sanae BERRED** & Khadija BERRED (2021). Climate Change Issues, Challenges, and Impacts in Terms of Rural Geo-biological and Cultural Tourism Activity Development in Semiarid Areas: a Case Study from Tata, Bani Geopark (Anti-Atlas, South Morocco). *Geoheritage*, 13(4), 1-11.

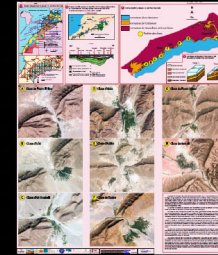
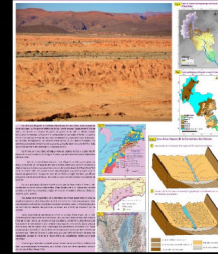
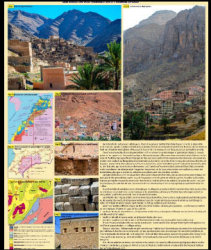
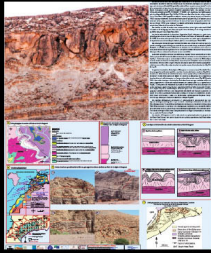
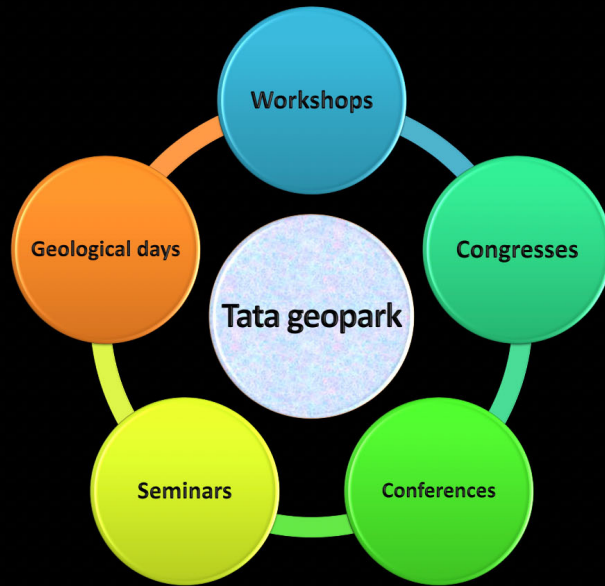
- **Sanae BERRED**, Driss FADLI, Felice Di Gregorio & Khadija BERRED (2020). Geological and landscape particularities of Issafen-style chevron pattern in Tata region (Anti-Atlas, South Morocco). *Arab J Geosci* 13, 689. <https://doi.org/10.1007/s12517-020-05713-z>

- **Sanae BERRED**, Driss FADLI, Mohammed El WARTITI, Mohammed ZAHRAOUI, Khadija BERRED and Ridouane SADKI (2019). Geomorphosites of the Semi-arid Tata Region: Valorization of an Unknown Geoheritage for Geotourism Sustainable Development (Anti-Atlas, South Morocco). *Geoheritage*. October. <https://doi.org/10.1007/s12371-019-00414-w>

- **Sanae BERRED**, Driss FADLI, Khadija BERRED (2019). Aerial interference of Hercynian folds and their morphological peculiarities in the Bani Geopark of southern Morocco. *Arab J Geosci*. Volume 12, Number 11, Page 1. June, 12: 351. <https://doi.org/10.1007/s12517-019-4537-3>

- **Sanae BERRED**, Driss FADLI (2016) Géosites et Géomorphosites témoignant de l'instabilité synsédimentaire des séries carbonatées de l'Ediacarien terminal et du Cambrien inférieur (Géoparc du Jbel Bani, Sud Marocain). *Notes et Mémoires du service Géologique du Maroc* :15

Tata aspiring geopark project



Tata aspiring geopark project

Oral presentations

Sanae BERRED : Driss FADLI, Mohamed EL WARTITI, Mohamed ZAHRAOUI, Barbara ALDIGHERI, Ahmed EL ABOUDI (2019) "LE GÉOHÉRITAGE DE LA PROVINCE DE TATA : UN PATRIMOINE NATUREL POUR UN DÉVELOPPEMENT GÉOTOURISTIQUE (BANI GEOPARK DU SUD MAROCAIN) », Workshop internationale 29 ottobre Milano (Italia), 30 ottobre- 2 novembre 2019 Tozeur (Tunisie), sous le thème : La valorizzazione del patrimonio geologico e geomorfologico; vettore di sviluppo del turismo sostenibile.

Sanae BERRED : Driss FADLI, Mohamed EL WARTITI, Mohamed ZAHRAOUI (2018) "Géotourisme dans le milieu oasien du « Bani Geopark » : développement durable pour un tourisme intégré du Sud marocain", Journée doctorale de l'Institut Scientifique/Université Mohammed V, sous le thème : une rencontre entre les jeunes chercheurs, le grand public et les professionnels, à Rabat le 15 décembre 2018.

Sanae BERRED : Driss FADLI, Mohamed EL WARTITI, Mohamed ZAHRAOUI (2018) "Le patrimoine géologique du Bani geopark : identification, valorisation et évolution de leur vulnérabilité avec un approche conceptuelle de protection", séminaire national sur les sites géologiques remarquables « géosites de l'Algérie » à El Bayadh les 23, 24, 25 et 26 octobre 2018 (communication orale).

Sanae BERRED : Driss FADLI (2016) « Géosites et Géomorphosites témoignant de l'instabilité synsédimentaire des séries carbonatées de l'Ediacarien terminal et du Cambrien inférieur (Géoparc du Jbel Bani, Sud Marocain) », Premières journées géologiques du Maroc, siège du ministère d'énergie des mines de l'eau et de l'environnement à Rabat du 10au 12 mai 2016.



Tata aspiring geopark project

Communication

Social media

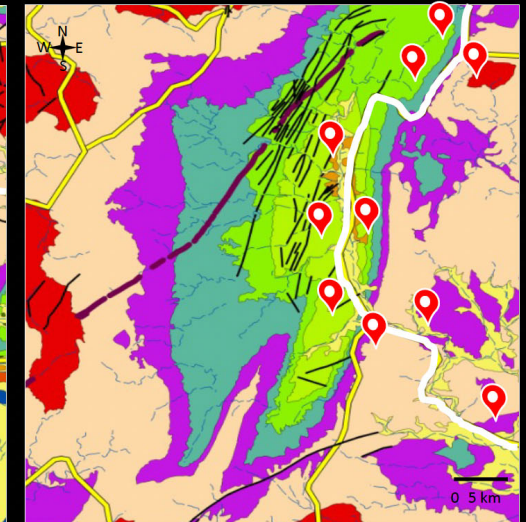


Tata aspiring geopark project

Geotouristic geotrails



Imitek-Tagmoute geotrail



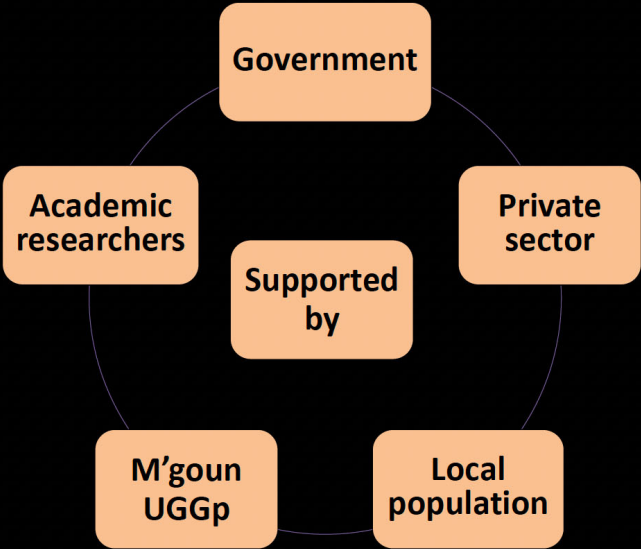
Issafen geotrail

Tata aspiring geopark project

Geotouristic geotrails

Geotrails	Difficulty	Type	Theme	Duration
Fam El Hisn-Tamanart	Low	All public	Geology/culture	1 - 2 days
Aguinane gorge	Medium	All public	Geology/culture	1- 2 days
Issafen-Tata	Medium	School/sports	Geology/culture	1 day
Akka-Tata	Low	All public	Geology/culture	1 day
Tadakoust-Ait Ouabelli	Medium	All public	Geology/culture	1 day
Tamzrart-Ait Ouabelli	Medium	All public	Geology/culture	1 jour
Tata-Akka-Ighane	Low	All public	Geology/culture	1 day
Akka-Ighane-Tissint	Low	All public	Geology/culture	1 day
Tissint-Foum Zguid	Low	All public	Geology/culture	1 day
Foum Zguid-Alougoum	Medium	All public	Geology/culture	1 à-2 days
Tagmoute gorge	Low	All public	Geology/culture	1 day

Tata aspiring geopark project



Tata aspiring geopark project

Issues & challenges

Floods

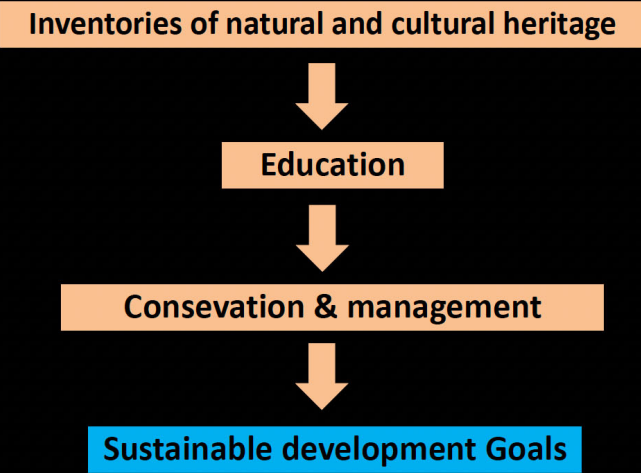
Sand progress

Weathering

Fires

Drought

Conclusion & perspectives





Thank you