THE ALPARRAY SWATH-D EXPERIMENT INSTALLATIONS IN NE ITALY

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**The AlpArray SWATH-D experiment.** The understanding of tectonic processes in the Alps has advanced significantly during the last three decades mostly via tomography, yielding information on the structure of the upper mantle below the Alps (Handy *et al.*, 2015). Subducted oceanic lithosphere forms a broad anomaly resting on but not penetrating the 670 km discontinuity under the Alps. More shallow slabs imaged below the Alpine arc are interpreted as subducted continental lower lithosphere. However, important issues like the polarity of subduction under
the eastern Alps and the slab geometry at the transition to the Pannonian realm are still under debate.

Several studies, e.g. Lippitsch et al. (2003), Kissling et al. (2006), Mitterauer et al. (2011), constructed tomographic images of the upper mantle between 60 km and 500 km depth (Fig.1). They found a steeply to vertically dipping “shallow slab” below the eastern Alps down to a depth of ~250 km, interpreted as European lower lithosphere detached from the crust and subducted during post-collision convergence between Adria and Europe. Between 350 km and 400 km depth, a “deep slab” extends from below the central eastern Alps to under the Pannonian realm, interpreted as subducted lithosphere of the Alpine Tethys. At greater depth, there is a continuous transition to the high velocity anomaly above the 670 km discontinuity. Due to the sparse station network at that time typical resolution in the upper-most mantle has been on the order of 70 x 70 x 30 km (lat x lon x depth).

Based on these results the SWATH-D experiment will allow testing the hypothesis that re-organizations of Earth’s mantle during the collision of tectonic plates have both immediate and long-lasting effects on earthquake distribution, crustal motion and landscape evolution in mountain belts.

This aim can only be achieved by integrating geophysical 3D images of the entire crust-mantle system with geologic observations and modelling in time, the 4th dimension. The primary target of the AlpArray network is imaging the large-scale configuration of the slabs and the variation of crustal and mantle properties throughout the whole Alps. However, the average station spacing of 40+ km in the AlpArray “backbone” network is not sufficient to image the details of the collision in the central zone. As generally, at least one station is required within the epi-central distance, this is also not enough to determine reliably the absolute depths of earthquakes <~15 km deep. Furthermore, due to the obliqueness of Ps conversion phases used in receiver function imaging, rays from neighbouring AlpArray network stations only start to overlap at a depth of ~65 km, i.e. too deep to image reliably the 3D geometry of crust-mantle transition and the shallowest slab geometry. Finally, the relatively small scale of geological variation in the central and eastern Alps requires denser spatial sampling than provided by the AlpArray network to model the 3D crustal structure adequately. An example for this is the Tauern Window, a block of European derived crustal units surrounded by African derived units only ~40 km wide in N-S direction.

The SWATH-D experiment focuses on the provision of seismic data from a dense seismic network in the Central and Eastern Alps. This dense deployment of 154 stations will complement the larger-scale AlpArray “backbone” network (AlpArray, 2016). SWATH-D will provide high-

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**Fig. 1 - Structure of the upper mantle – tomographic P-velocity depth slice between 135 and 165 km depth (after Lippitsch, 2003). The red box indicates the location of the SWATH-D experiment, covering the two slabs and the suggested gap between them.**
resolution images from the surface into the upper mantle. SWATH-D focuses on a key area of the Alps where e.g. the hypothesized flip in polarity is suggested to occur, and where the TRANSALP experiment has imaged a jump in the Moho (TRANSALP Working Group, 2002). The data created in this project will be used directly by 20 individual proposals of the MB-4D Priority Program (Mountain Building Processes in Four Dimensions, 2017) of the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft, 1952), and data products derived from it will contribute to an additional 13 proposals. SWATH-D is thus an important link within the MB-4D Priority Program and the international AlpArray communities and a scientific service to many of the proposals within the DFG Priority Program community.

Given the extension of the SWATH-D experiment in NE Italy, a specific Memorandum of Understanding between the GFZ and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS, http://www.inogs.it/) has been signed for the execution of the experiment itself.

**SWATH-D experiment installations in NE Italy.** To derive the best possible and highly resolved 3D images from crust to mantle a dense network of seismological stations is therefore required. The 154 seismic stations that will be installed are illustrated in Fig. 2.

Sites were scouted in summer 2017 and deployment is currently under way (autumn 2017). Seismic stations will consist of a digital recorder (EarthData EDR-210 / EarthData PR6-24 / Cube3) and a broadband sensor (Guralp CMG-3 ESP compact / Trillium 120 PA / Trillium compact). Depending on the specific site conditions, stations will run on mains power (where available, buffered by batteries), autonomously with air batteries or exceptionally on solar power (buffered by batteries). The stations will continuously run at a sample rate of 100 samples per second; accurate timing is provided through GPS synchronization. The station deployment will follow the AlpArray “Standards for seismic stations and data management” (2016) and the “Technical strategy for the mobile seismological components of AlpArray” (Brisbourne et al., 2013). The higher station density and resulting reduced flexibility in station siting of SWATH-D will require some compromises with respect to achievable noise levels.

Fig. 2 - Locations of the SWATH-D experiment installations.
Wherever possible, stations will be equipped with modems to allow at least for state-of-health information on a regular, automatic and wireless basis; where achievable bandwidths allow, we will also download continuous data over these links. However, given the alpine environment and the constraints on station spacing, some stations will have insufficient mobile network coverage; such that the data downloads (from internal mass storage within the recorder) will still require service trips. Before installation of instruments, all sites selected in a reconnaissance trip by three+ groups (average of 2 scouted stations per group and day). Installation will be done in Summer 2017 by at least 4 groups (average of 1 station installation per group and day; estimates based on our experiences with previous experiments). During the ca. 2-year run-time of the instruments, we plan three servicing trips to the stations on average. Demobilization is planned for spring/summer 2019. Data preparation will start with the first service trip in 2018, or as soon as online data become available.

The logistic accessibility of planned alpine locations of SWATH-D has been checked. Due to the dense network of Alpine huts, local roads to alpine pastures (“Almen” and “malghe”) and forestry tracks, almost all planned stations are within 1 to 2 km of simple access (mostly by vehicle). From our experience during TRANSALP and the information from the colleagues in EASI project (2014), we estimate that we will be able to deploy more than 75 % of the stations within a 2 to 4 km radius of the intended location. This assures the feasibility of deploying such a station network in this area – albeit with some tolerable modifications.

The final configuration of the deployment will look slightly different, depending on local conditions. Planned stations of the regular grid within SWATH-D closer than 5 km to an AlpArray “backbone” network station are omitted. This results in 145 stations in SWATH-D, covering also the high seismicity area east of Lake Garda. We think that the present configuration of SWATH-D is the best to satisfy the needs of most of the groups applying to the MB-4D Priority Program. A few examples of SWATH installations in Italy follow (Fig. 3).

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