A model to access geochronological data for the Geological Survey of Austria

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Introduction:

Since its beginnings in the 20th century, geochronology gives a unique possibility to give an absolute age to geological features. A wide range of methods allows for temporal constraints on geodynamic processes such as the emplacement of igneous rocks, metamorphic and tectonic events, cooling and exhumation of basement rocks as well as erosion and deposition of sediments.

Nowadays, the huge amount of available geochronological data provides a basis for geodynamic models and a modern understanding of the associated geological processes. However, the information is often scattered over several publications, buried in inaccessible articles from historical ("grey") literature or it does not meet modern standards (e.g. ages calculated using outdated decay constants). Thus, the collection and assessment of geochronological data is an essential, but time-consuming and reoccurring task for many geological projects. Additionally, best practice in scientific research calls for a meticulous documentation of new data to allow for the reproducibility of results.

To improve the accessibility and documentation of geochronological data at the Geological Survey of Austria, a project was set up to amalgamate geochronological data in a structured database. The data collection covers common dating methods and isotope systems including cosmogenic isotopes. To make them available as a point layer for geographic information systems (GIS), the data model assigns dated minerals from publications as well as the necessary background information of the samples to a geographical located point (GCHRON_number). The storage of the whole dataset allows, as simple as possible, a recalculation of geochronological data.

Data:

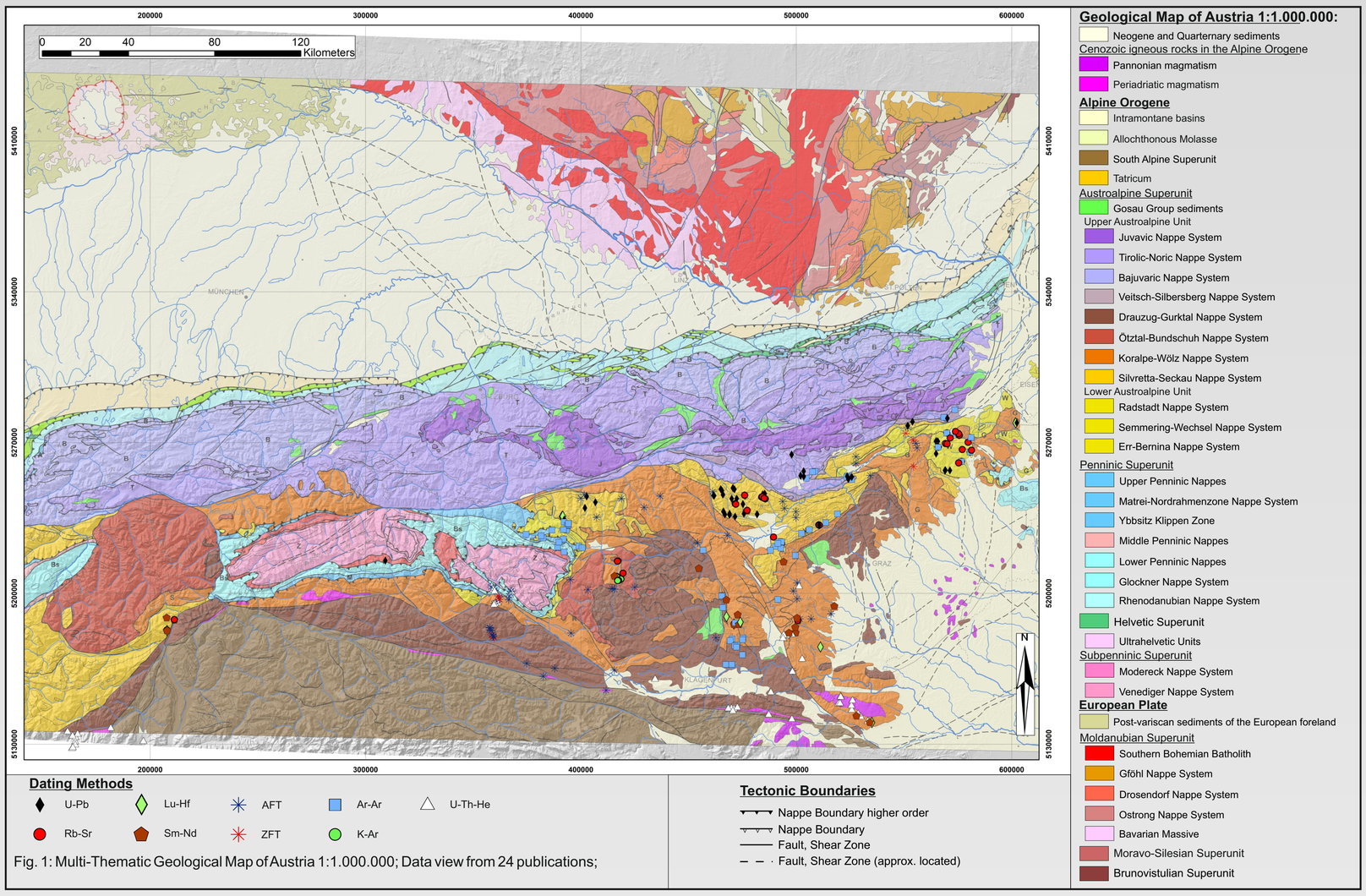

Fig. 1: Multi-Thematic Geological Map of Austria 1:1.000.000; Data view from 24 publications;

Implementation:

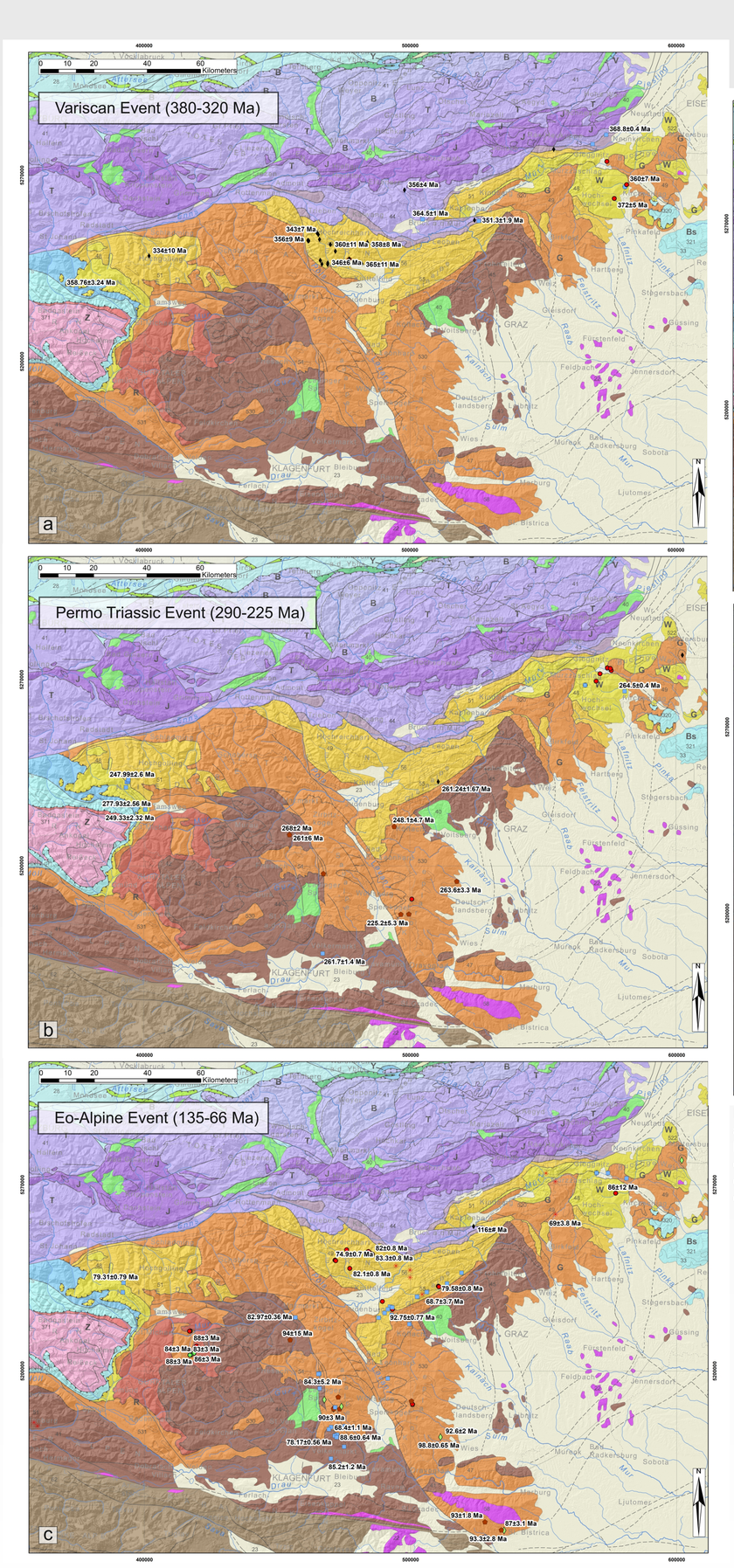

Fig. 3: ArcGIS query plotted on the Multi-Thematic Geological Map of Austria
a: Data related to the Variscan event (380-320 Ma)
b: Data from to the Permo Triassic event (290-225 Ma);
c: Data assinged to the Eo-Alpine event (135-66 Ma) (nomenclature from Hintersberger et al., 2017).
d: Data interpreted as formation age; U-Pb dating method
e: Cooling ages, Apatite fisson track & U-Th-He method

ID	ID_	Material	NR	URSPRNR	Sm_ppm	147Sm_144Nd	143Nd_14	143Nd_144N	Altersbereinc	MSWD	n_PunkteAr	e_t_Nd	t_Ma	e_Nd_0	T_DM_Ga	Zerfallskonsta	Nd_Standar	143Nd_144Nd_Std	COMMENT
1	0006	Grt	GCHRON_0006	RSP320 Grt	1,814	2,912	0,5806	0,512416	0,000008	WR-Grt		2	1,18	84	6,25		La Jolla	0,511846±0,000008	
2	0006	WR	GCHRON_0006	RSP320 WR	6,2	33,61	0,1132	0,512271	0,000007	WR-Grt							La Jolla	0,511846±0,000008	
3	0013	Grt	GCHRON_0013	RS6/95 Grt3	3,19	7,076	0,2725	0,513219	0,000009	Grt-Ep							La Jolla	0,511846±0,000008	
4	0014	Grt	GCHRON_0014	RS6/95 Grt1	29,01	1,114	1,3174	0,514053	0,000016	Grt-Ep							La Jolla	0,511846±0,000008	
5	0014		GCHRON_0014	RS6/95 Ms	6,28	20,14	0,1885	0,511966	0,000007	Grt-Ep							La Jolla	0,511846±0,000008	
6	0014	Ep	GCHRON_0014	RS6/95 Ep	1721	279,7	0,0962	0,513907	0,000007	Grt-Ep							La Jolla	0,511846±0,000008	
7	0014	Grt	GCHRON_0014	RS6/95 Grt2	2,621	2,649	0,5981	0,512809	0,000034	Grt-Ep							La Jolla	0,511846±0,000008	
8	0015	Grt	GCHRON_0015	RS6/95 Grt	1,961	5,006	0,2368	0,513995	0,000008	Grt-Ep		2		94			La Jolla	0,511846±0,000008	
9	0015	Ep	GCHRON_0015	RS6/95 Ep	29,01	158,9	0,1104	0,513917	0,000012	Grt-Ep							La Jolla	0,511846±0,000008	
10	0018	Grt	GCHRON_0018	MM3 grt1	1,891	1,137	0,3834	0,513	0,000009	WR-Grt	0,32	3		374		6,54*10-12 *a-1	La Jolla	0,511846±0,000001	
11	0018	Grt	GCHRON_0018	MM3 grt2	1,838	1,187	0,3838	0,513	0,000008	WR-Grt						6,54*10-12 *a-1	La Jolla	0,511846±0,000001	
12	0018	WR	GCHRON_0018	MM3 WR	2,944	0,761	1,563	0,5124	0,000003	WR-Grt						6,54*10-12 *a-1	La Jolla	0,511846±0,000001	
13	0150	Ap	GCHRON_0150	BT712 Ap	37,433	45,574	0,4974	0,512288	0,000008	Grt1-Grt2						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
14	0152	Grt	GCHRON_0152	BT712 Grt 1	0,449	0,077	3,7871	0,514322	0,00005	WM2						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
15	0153	Grt	GCHRON_0153	BT712 Grt 2	0,585	0,074	4,796	0,514721	0,000018	WM2						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
16	0153	WR	GCHRON_0153	BT712 WR1	7,233	9,654	0,453	0,512887	0,000007					240	-2,99	6,54*10-12 *a-1	La Jolla	0,511850±0,00001	e 240 Nd
17	0153	WR	GCHRON_0153	BT712 WR2	7,375	10,044	0,4439	0,512878	0,00005					240	-2,89	6,54*10-12 *a-1	La Jolla	0,511850±0,00001	e 240 Nd
18	0153	Ms	GCHRON_0153	BT712 WM1				0,512836	0,00002							6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
19	0153	Ms	GCHRON_0153	BT712 WM2	0,067	0,095	0,42482	0,51267	0,00002							6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
20	0153	Fsp + Qtz	GCHRON_0153	BT712 LF	0,515	0,682	0,4571	0,512683	0,000016							6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
21	0156	Grt	GCHRON_0156	937234a Grt; 1c	0,993	0,267	2,2552	0,53575	0,000016	WR-Grt						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
22	0156	WR	GCHRON_0156	937234a WR	2,473	2,73	0,5377	0,512174	0,000009	WR-Grt		3	-6,41	255,6		6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
23	0157	Grt	GCHRON_0157	937234a Grt; 2c	0,965	0,337	1,7325	0,514962	0,000016	WR-Grt						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
24	0158	Grt	GCHRON_0158	957068 Grt	1,614	0,557	1,75215	0,514468	0,000075	WR-Grt						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	e Nd_WR
25	0159	Grt	GCHRON_0159	957068 Grt xx	1,393	0,117	7,21423	0,525557	0,000082	WR-Grt						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
26	0159	WR	GCHRON_0159	957068 WR	3,75	11,335	0,20359	0,512214	0,000011	WR-Grt	1,28	3	-8,49	222,4		6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
27	0160	Grt	GCHRON_0160	957146 Grt	1,7	0,637	1,61358	0,513849	0,000016							6,54*10-12 *a-1	La Jolla	0,511850±0,00001	mixed age
28	0161	Tur	GCHRON_0161	957146 Tour	0,579	2,107	0,16617	0,512138	0,000013							6,54*10-12 *a-1	La Jolla	0,511850±0,00001	mixed age
29	0161	WR	GCHRON_0161	957146 WR	2,268	5,703	0,24038	0,512201	0,000007				-9,98	240		6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
30	0162	Grt	GCHRON_0162	963KWT Grt 2	0,563	0,054	6,3605	0,516184	0,000196	WR-Grt						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
31	0162	Grt	GCHRON_0162	963KWT Grt	0,262	0,018	6,595			WR-Grt						6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
32	0162	WR	GCHRON_0162	963KWT WR	0,377	0,508	0,4482	0,512799	0,000047	WR-Grt				240	-4,56	6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
33	0168	2m	GCHRON_0168	WAP424 2c; 1d	47,904	61,173	0,4672	0,512799	0,00001							6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
34	0169	2m	GCHRON_0169	WAP424 2c, 2n	0,356	0,431	0,49914	0,512947	0,00006							6,54*10-12 *a-1	La Jolla	0,511850±0,00001	badly definec
35	0169	WR	GCHRON_0169	WAP424 WR	5,515	20,884	0,15965	0,512622	0,000003			3	0,92	87,9		6,54*10-12 *a-1	La Jolla	0,511850±0,00001	
36	0170	WR	GCHRON_0170	BT933 wr(G)	4,722	14,38	0,1985	0,513033	0,000003	WR-Grt	0,39	5		260	7,65	6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	
37	0170	Grt	GCHRON_0170	BT933 Grt	0,256	0,047	3,2851	0,514052	0,000027	WR-Grt	0,39		7,7	90,1		6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	
38	0171	Omp	GCHRON_0171	BT958 Omp-1	1,637	1,365	0,2941	0,513088	0,000007				7,9	78		6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	
39	0172	Omp	GCHRON_0172	BT958 Omp-2	1,088	1,464	0,4493	0,513182	0,000004				7,7	86,9		6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	
40	0173	Grt	GCHRON_0173	BT958 Grt-1	0,742	0,109	4,1049	0,51316	0,000024				7,8	90,8		6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	
41	0174	Grt	GCHRON_0174	BT958 Grt-2	0,6	0,09	4,0156	0,515287	0,000091				7,9	89,5		6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	
42	0174	WR	GCHRON_0174	BT958 wr (G)	4,396	13,09	0,2031	0,513042	0,000003	WR-Grt	0,39	4		260	7,67	6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	
43	0176	Omp	GCHRON_0176	SKP2 Omp	1,327	1,49	0,5393	0,513268	0,000007		1,6	5	8,2	95,5		6,54*10-12 *a-1	La Jolla	0,511850 ± 0,000001	

Fig. 4: Detail table for the Sm-Nd dating method.

Data structure:

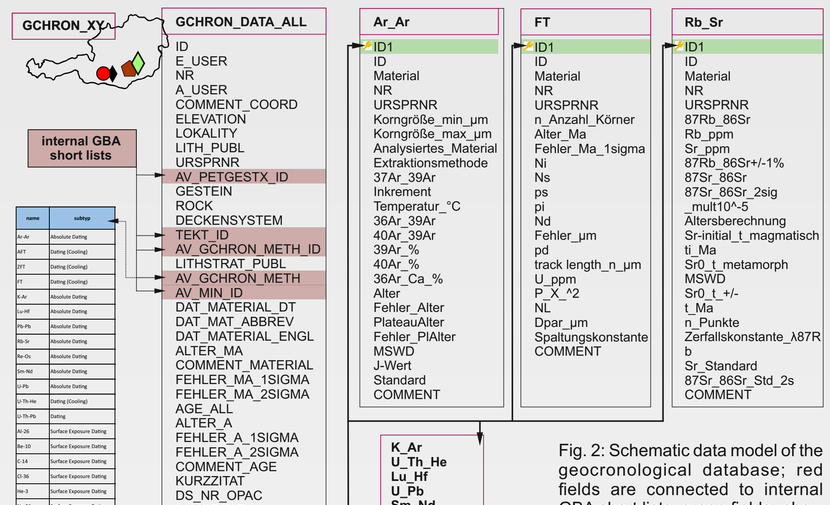

Fig. 2: Schematic data model of the geocronological database; red fields are connected to internal GBA short lists, green fields show the connection in the data model.

The data model is structured in different data tables, directly linked to a key table including the GCHRON numbers (ID1), which is linked to the coordinate and detailed information of the dated mineral, lithology, geological unit and the corresponding geochronological method. Detailed information for each method is provided in separate tables. Several results from single minerals and from different methods can be attributed to one GCHRON number. At this stage, 440 results from the U/Pb, Rb/Sr, Sm/Nd, K/Ar, Ar/Ar, Fisson Track, U-Th/He and Lu/Hf dating of various minerals and whole rock material are included, associated to the method and dated material. Of course, calculated ages are also provided. In addition a link to the reference, to open access respectively free access publications in the library of the Geological Survey, is provided. At the present stage, data from around 24 publications have been processed.

Literature:

Haas, I., Eichinger, S., Haller, D., Fritz, H., Nievoll, J., Mandl, M., Hippler, D. & Hauzenberger, C., 2020: Gondwana fragments in the Eastern Alps: a travel story from U/Pb zircon data. - Gondwana Research, 77, 204-222.

Habler, G., Thöni, M. & Sölva, H., 2006: Tracing the high pressure stage in the polymetamorphic Texel Complex (Austroalpine basement unit, Eastern Alps): P–T–t–d constraints. - Mineralogy and Petrology, 88, 269-296.

Handler, R., Neubauer, F., Hermann, S. & Dallmeyer, R. D., 1999: Silurian-Devonian 40Ar/39Ar Mineral Ages from the Kaintaleck Nappe: Evidence for Mid-Paleozoic Tectonothermal Activity in Upper Austroalpine Basement Units of the Eastern Alps (Austria). - Geologica Carpathica, 50, 229-239.

Heberer, B., Lee-Reverman, R., Guiditta-Fellin, M., Neubauer, F., Dunkl, I., Zattin, M., Seward, D., Genser, J., Brack, P., 2017: Postcollisional cooling history of the Eastern and Southern Alps and its linkage to Adria indentation.- International Journal of Earth Sciences, 106, 5, 1557-1580.

Hejl, E., 1998: Über die känozoische Abkühlung und Denudation der Zentralalpen östlich der Hohen Tauern - eine Apatit-Spaltspurenanalyse. - Mitteilungen der Österreichischen Geologischen Gesellschaft, 89, 179-199, Wien.

Huang, Q., Genser, J., Liu, Y., Neubauer, F., Yuan, S., Bernroider, M., Guan, Q., Jin, W., Yu, S. & Chang, R., 2021: Cambrian-Ordovician continental magmatic arc at the northern margin of Gondwana: Insights from the Schladming Complex, Eastern Alps. - Lithos, 388-389, https://doi.org/10.1016/j.lithos.2021.106064.

Legrain, N., Stüwe, K. & Wölfler, A., 2014: Incised relict landscapes in the eastern Alps. - Geomorphology, 221, 124-138.

Liu, Y., Genser, J., Handler, R., Friedl, G. & Neubauer, F., 2001: 40Ar/39Ar muscovite ages from the Penninic-Austroalpine plate boundary, Eastern Alps. - Tectonics, 20, 526-547.

Mandl, M., Kurz, W., Hauzenberger, C., Fritz, H., Klötzli, U. & Schuster, R., 2018: Pre-Alpine evolution of the Seckau Complex (Austroalpine basement/Eastern Alps): Constraints from in-situ LA-ICP-MS U/Pb zircon geochronology. - Lithos, 296-299, 412-430.

Miladinova, I., 2019: The subduction of continental crust - insights from eclogite geochronology and petrology. - Dissertation, Universität Bonn, 172 S., Bonn.

Müller, W., Dallmeyer, D. R., Neubauer, F. & Thöni, M., 1999: Deformation-induced resetting of Rb/Sr and 40Ar/39Ar mineral systems in a low-grade, polymetamorphic terrane (Eastern Alps, Austria). - Journal of the Geological Society, London, 156, 261-278.#

Neubauer, F., Frisch, W. & Hansen, B. T., 2002: Early Palaeozoic tectonothermal events in basement complexes of the eastern Greywacke Zone (Eastern Alps): evidence from U-Pb zircon data. - International Journal of Earth Sciences, 91, 775-786.

Neubauer, F., Liu, Y., Chang, R., Yuan, S., Yu, S., Genser, J., Liu, B. & Guan, Q., 2020: The Wechsel Gneiss Complex of Eastern Alps: an Ediacaran to Cambrian continental arc and its Early Proterozoic hinterland. - Swiss Journal of Geosciences, 113, 1, https://doi.org/10.1186/s00015-020-00373-3.

Pfingstl, S., Kurz, W., Schuster, R. & Hauzenberger, C., 2015: Geochronological constrains on the exhumation of the Austroalpine Seckau Nappe (Eastern Alps). - Austrian Journal of Earth Sciences, 108, 1, 172-185, Vienna.

Putis, M., Korikovsky, S. P. & Pushkarev Y. D., 2000: Petrotectonics of an Austroalpine Eclogite-Bearing Complex (Sieggraben, Eastern Alps) and U-Pb Dating of Exhumation. - Jahrbuch der Geologischen Bundesanstalt, 142, 1, 73-93, Wien.

Schuberth-Hlavač G., 2021: Geologie des hinteren Neuhofgrabens (Steiermark): Petrologie, Geochemie, Geochronologie ostalpiner Kristallineinheiten. - Masterarbeit, Universität Wien, 143 S., Wien.

Schuster, R. & Frank, W., 1999: Metamorphic evolution of the Austroalpine units east of the Tauern Window: indications for Jurassic strike slip tectonics. - Mitteilungen der Österreichischen Geologischen Gesellschaft, 42 (1999), 37-58, Wien.

Thöni, M., 2002: Sm-Nd isotope systematics in garnet from different lithologies (Eastern Alps): age results, and an evaluation of potential problems for garnet Sm-Nd chronometry. - Chemical Geology, 185, 255-281.

Thöni, M. & Miller, C., 2000: Permo-Triassic pegmatites in the eo-Alpine eclogite-facies Koralpe complex, Austria: age and magma source constraints from mineral chemical, Rb–Sr and Sm–Nd isotope data. - Schweizerische Mineralogische und Petrographische Mitteilungen, 80, 169-206.

Thöni, M., Miller, C., Blichert-Toft, J., Whitehouse, M. J., Konzett, J. & Zanetti, A., 2008: Timing of high-pressure metamorphism and exhumation of the eclogite type-locality (Kupplerbrunn–Prickler Halt, Saualpe, south-eastern Austria): constraints from correlations of the Sm–Nd, Lu–Hf, U–Pb and Rb–Sr isotopic systems. - Journal of metamorphic Geology, 26, 561–581.

Van Gelder, I. E., Willingshofer, E., Andriessen, P. A. M., Schuster, R. & Sokoutis, D., 2020: Cooling and Vertical Motions of Crustal Wedges Prior to, During, and After Lateral Extrusion in the Eastern Alps: New Field Kinematic and Fission Track Data from the Mur-Mürz Fault System. - Tectonics, 39, https://doi.org/10.1029/2019TC005754.

Wiesinger, M., Neubauer, F., Handler, R., 2006: Exhumation of the Saualpe eclogite unit, Eastern Alps: constraints from 40Ar/39Ar ages and structural investigations. - Mineralogy and Petrology, 88, 149-180.

Wölfler, A., Dekant, C., Danišik, M., Kurz, W., Dunkl, I., Putiš, M. & Frisch, W., 2008: Late stage differential exhumation of crustal blocks in the central Eastern Alps: evidence from fission track and (U–Th)/He thermochronology. - Terra Nova, 20, 5, 378-418.

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