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2	Carboniferous high-pressure metamorphism of Ordovician protoliths
3	in the Argentera Massif (Italy), Southern European Variscan belt
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24 ABSTRACT

25 The age of high-pressure metamorphism is crucial to identify a suitable tectonic 26 model for the vast Variscan orogeny. Banded HP granulites from the Gesso-Stura 27 Terrain in the Argentera Massif, Italy, have been recently described (Ferrando et al., 28 2008) as relict of high-pressure metamorphism in the western part of the Variscan 29 orogen. Bulk rock chemistry of representative lithologies reveals intermediate silica 30 contents and calc-alkaline affinity of the various cumulate layers. Enrichment in 31 incompatible elements denotes a significant crustal component in line with intrusion 32 during Ordovician rifting. Magmatic zircon cores from a PI-rich layer yield scattered 33 ages indicating a minimum protolith age of 486±7 Ma. Carboniferous zircons 34 (340.7±4.2 and 336.3±4.1 Ma) are found in a PI-rich and a PI-poor layer, 35 respectively. Their zoning, chemical composition (low Th/U, flat HREE pattern and Ti-36 in-zircon temperature) and deformation indicate that they formed during the high-37 pressure event before decompression and mylonitisation. The proposed age for high-38 pressure metamorphism in the Argentera Massif proves that subduction preceded 39 anatexis by less than 20 Ma. The new data allow a first-order comparison with the 40 Bohemian Massif, which is located at the eastern termination of the Variscan orogen. 41 Similarities in evolution at either end of the orogen support a Himalayan-type 42 tectonic model for the entire European Variscides.

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Keywords HP granulites, U-Pb geochronology, zircon, Variscan belt.

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46 **1. Introduction**

47 The Variscan orogeny (~380-300 Ma) is the geological event most largely 48 represented in the basement of the European continent. It was assembled between 49 Ordovician and Carboniferous from the larger collision of Gondwana with the 50 northern plate of Laurentia-Baltica, which involved the microplates of Avalonia and 51 Armorica (Matte, 2001). Variscan units extend from southern Spain (the Ibero-52 Armorican termination) to Poland (the Bohemian Massif). Large remnants of Variscan 53 basement are preserved in the southern Variscides, within the Alpine chain, where 54 they are located in external positions. In the Western and Central Alps, such 55 remnants are identified as External Crystalline Massifs, which record the general 56 evolution common to all Pangean Europe (von Raumer et al., 2009).

57 A series of tectonic models have been proposed for the assembly of this vast 58 orogen. Early models favour Himalayan-style collision with subduction of a small 59 ocean rapidly followed by intense continent-continent collision leading to Barrovian 60 metamorphism and extensive crustal anatexis in the Late Carboniferous (summary in 61 O'Brien, 2000). More recently, Andean-style tectonics has been proposed, at least for 62 the eastern termination of Variscan Europe (Bohemian Massif). The Andean model 63 prefers a long lasting subduction process with development of blueschist terranes, 64 extensive arc magmatism in the upper plate and formation of back-arc basins 65 (Schulmann et al., 2009).

One crucial piece of information that is necessary in order to better define a
suitable geodynamic model for the Variscan orogen is the absolute and relative ages
of subduction (as seen in relicts of eclogites) versus the onset of regional anatexis.
Whereas the latter event is reasonably well constrained across the western European
Variscan basement at around 320-310 Ma (e.g. Demoux et al., 2008; Rubatto et al.,
2001), the scarcity of eclogite facies rocks and their poor preservation have

hampered robust dating of Variscan high-pressure (HP) assemblages. Some
constraints exist for the eastern part of the orogen (Bohemian Massif, Kröner et al.,
2000; Schulmann et al., 2005), but ages of HP assemblages are lacking in the
western part. This contribution presents the first geochronological constraints
(SHRIMP U-Pb dating of zircon) on HP assemblages recently described in the
Argentera Massif. This is a crucial record for the External Crystalline Massifs and for
most of the western portion of the European Variscan orogen.

79

80 **2. Geological background and previous geochronology**

81 The Argentera Massif is located in NW Italy, on the border with France. It is the 82 southernmost of the External Crystalline Massifs, which are a series of large crustal 83 bodies aligned on the external part of the western and central Alpine chain (Fig. 1a). 84 They are generally composed of a complex Variscan basement intruded by Permian 85 granitoids. Alpine overprint in these Massifs is weak and commonly limited to shear 86 zones. The exhumation of the External Crystalline Massifs from below the Alpine 87 sediments initiated in the Miocene (e.g. Bigot-Cormier et al., 2006), at the end of the 88 Alpine orogeny.

The Argentera Massif is largely composed of Variscan migmatites with abundant relicts of pre-anatectic rock types. At the centre of the Massif, a post-Variscan granite (the Central Granite, Fig. 1b) cuts across the foliation. The Massif is subdivided into two major complexes on the basis of different lithological associations: the Gesso-Stura Terrain in the NE, and the Tinée Terrain in the SW. A large shear zone, the Ferriere-Mollières Line, separates the two Terrains. The studied Frisson Lakes area is located at the eastern tip of the Gesso-Stura Terrain, which is

96 mainly composed of migmatitic ortho- and para-gneisses, with various intrusive 97 bodies from mafic (Bousset-Valmasque Complex) to granitic in composition. 98 A Late- to Mid-Carboniferous age (\leq 323± 12 Ma) of migmatisation in the 99 Argentera Massif has been proposed on the basis of a zircon lower intercept age 100 obtained for the Meris eclogite (Rubatto et al., 2001), the only relict of fresh eclogite 101 so far dated. Migmatisation in the Gesso-Stura Terrain must have occurred after the 102 intrusion of monzonites (332±3 Ma, Rubatto et al., 2001), which show signs of 103 partial melting, and before the intrusion of the Central Granite (~285-293 Ma, 104 Ferrara and Malaroda, 1969). For the Tinée Terrain, an earlier age (~350 Ma) of 105 metamorphism has been proposed on the basis of scattering Ar-Ar ages of muscovite 106 from gneisses (Monié and Maluski, 1983). Alpine low-grade overprint along shear 107 zones occurred in or before the Early Miocene (Corsini et al., 2004). 108 Additional constraints on Variscan migmatisation come from the nearby massif of 109 Tanneron (Fig. 1a), SE France, where migmatitic rocks contain monazites dated 110 between ~317 and 309 Ma (Demoux et al., 2008). In contrast, in Variscan Corsica, a 111 few zircon rims in a migmatitic paragneiss yielded an age of 338±4 Ma (Giacomini et 112 al., 2008), interpreted as dating "incipient migmatisation". 113 Geochronology of pre-anatectic events in the Argentera Massif is scarce and 114 mainly limited to magmatic activity. U-Pb zircon dating has returned the age of Late 115 Ordovician bimodal magmatism (~440 and 460 Ma) and of Carboniferous monzonites 116 (Rubatto et al., 2001). Previous attempts to date metamorphic rocks either returned 117 contrasting results (Paquette et al., 1989) or failed to date metamorphism (Rubatto 118 et al., 2001).

119

120 **3. Analytical methods**

121 Whole-rock major- and trace-element compositions were analysed at the Chemex 122 Laboratories (Canada) using ICP-AES (major elements) and ICP-MS (trace elements). 123 The precision for the analyses is better than 1% for major elements and better than 124 5% for trace elements. Zircons were prepared as mineral separates mounted in 125 epoxy and polished down to expose the grain centres. Cathodoluminescence (CL) 126 imaging was carried out at the Electron Microscope Unit, The Australian National 127 University with a HITACHI S2250-N scanning electron microscope working at 15 kV, 128 \sim 60 µA and \sim 20 mm working distance.

129 U-Pb analyses were performed using a sensitive, high-resolution ion microprobe 130 (SHRIMP II) at the Research School of Earth Sciences. Instrumental conditions and 131 data acquisition were generally as described by Williams (1998). The data were collected in sets of six scans throughout the masses. The measured ²⁰⁶Pb/²³⁸U ratio 132 133 was corrected using reference zircon (417 Ma, Black et al., 2003). Due to the 134 generally low Th/U in the analysed zircons, data were corrected for common Pb on the basis of the measured ²⁰⁸Pb/²⁰⁶Pb ratio and assuming concordance, as described 135 136 in Williams (1998). Age calculation was done using the software Isoplot/Ex (Ludwig, 137 2003) and assuming the common Pb composition predicted by Stacey and Kramers 138 (1975). U-Pb data were collected over a single analytical session with a calibration 139 error of 1.6 % (2 sigma). Finally, whenever the error of an average age was less 140 than the calibration error, an error of 1 sigma % was added in quadratic. Average 141 ages are quoted at 95% confidence level (c.l.).

Trace element analyses of zircon were performed on the grain mount with a Laser
Ablation – ICP-MS at the Research School of Earth Sciences, using a pulsed 193 nm
ArF Excimer laser with 100 mJ energy at a repetition rate of 5 Hz (Eggins et al.,
1998) coupled to an Agilent 7500 quadrupole ICP-MS. A spot size of 24 or 54 µm
was used according to the dimension of the growth zone of interest. External

147 calibration was performed relative to NIST 612 glass and internal standardisation 148 was based on stoichiometry silica. Accuracy of the analyses was evaluated with a 149 BCR-2G secondary glass standard and is always better than 15%. During the time-150 resolved analysis, contamination resulting from inclusions, fractures and zones of 151 different composition was monitored for several elements and only the relevant part 152 of the signal was integrated.

153

4. Sample description and chemistry

155 The two samples investigated are part of a mafic sequence, with mylonitic 156 structure, which conists of alternating layers (up to about 10 cm thick) of Pl-poor and 157 Pl-rich HP granulite, and of minor mafic boudins of Pl-poor HP granulite (Fig. 2 and 158 3a). The sequence is exposed at Frisson Lakes along the ridge between Val Grande 159 di Vernante and Val Gesso, N of Passo della Mena; in the small hill W of the lower 160 Frisson Lake (2055 m a.s.l.); along the polished outcrops S of the lower Frisson 161 Lake; and in the small hill E of the lower Frisson Lake (Fig. 2). In the field, the mafic 162 sequence constitutes an E-W band, about 200 m thick and 500 m long, surrounded 163 by Variscan migmatitic granitoid gneiss ("biotite anatexite" of Malaroda et al., 1970), 164 *i.e.* the dominant rock type in the area and across the entire Gesso-Stura Terrane. 165 The mafic sequence is elongated in a direction roughly parallel to the general trend 166 of the regional foliation in the Frisson area. However, at the outcrop scale, the 167 mylonitic foliation of the HP granulite is cut by the "igneous" fabric of the migmatitic 168 granitoid gneiss. Notably, no sign of melting is observed within the mafic sequence. 169 170 The two samples dated have similar assemblages, but different proportions of

171 major minerals. The PI-rich H*P* granulite (sample A1553, Fig 3a) has a banded

172 structure and contains plagioclase (35 vol.%), garnet (30 vol.%), quartz (20 vol.%),

173 and minor clinopyroxene, amphibole and biotite (15 vol.%). The mylonitic foliation 174 wraps around large garnet porphyroblasts (0.5-1 cm across) and smaller garnet 175 grains are found in the foliation (Fig. 3b). The Pl-poor HP granulite (sample A1554, 176 Fig 3c) occurs as a 10-15 cm thick mafic boudin (Fig. 3a). It mainly consists of 177 garnet (55 vol.%), clinopyroxene (20 vol.%) and amphibole (15 vol.%), whereas 178 plagioclase, biotite and quartz are rare (10 vol.%). The samples were part of the petrographical and petrological study of Ferrando et al. (2008) and we report here 179 180 only a brief summary of their conclusions.

181 Both rock types contain several generations of minerals which, coupled with 182 thermobarometric data, allow four metamorphic stages to be defined (Fig. 4). The 183 granulite-facies HP-HT peak (stage A: 735±15°C, ~1.38 GPa) is characterised by the 184 growth of the core of porphyroclastic garnet, and omphacite in stable association 185 with plagioclase, rutile \pm amphibole \pm quartz. The first decompression (stage B 186 ~710°C and 1.10 GPa) corresponds to the growth of the rim of porphyroclastic 187 garnet and omphacite in equilibrium with a second generation of plagioclase, rutile \pm 188 amphibole \pm quartz. Mylonitisation (stage C) was characterised by the growth of 189 neoblastic garnet, diopside, plagioclase, titanite \pm amphibole \pm quartz, and occurred 190 at amphibolite-facies conditions, i.e pressures of 0.85 GPa and still relatively HT191 (665±15°C). Finally, during stage D (500 < T< 625 °C; P < 0.59 GPa) plagioclase 192 and amphibole symplectites replaced the rims of garnet and clinopyroxene. No 193 evidence was found for the involvement of the mafic sequence in the anatexis 194 responsible for the Argentera migmatites. Lack of migmatisation of the mafic 195 sequence is attributed to its more refractive composition when compared to the 196 surrounding migmatites (Ferrando et al. 2008).

197 This *P-T* evolution was further supported by pseudosections, which, for the 198 chosen composition, predict mineral assemblages that are consistent with those

observed (Ferrando et al., 2008). This evolution and the peak metamorphic
conditions are similar to those recorded by relict eclogites within the Argentera
Massif (Val Meris eclogite, Colombo, 1996; Rubatto et al., 2001). This and other
arguments prompted Ferrando et al. (2008) to conclude that the Frisson Lakes HP
granulites and the Meris eclogites underwent the same metamorphism and that the
two rock types preserve different peak assemblages because of their different bulk
composition.

206

207 A mafic boudin (the Pl-poor HP granulite of sample A1554) and three layers of the 208 banded HP granulite sequence were analysed for bulk rock chemical composition 209 (Table 1). Major element chemistry indicates a common calc-alkaline composition for 210 all four samples. SiO₂ varies between 46 and 56 wt% according to the different 211 proportion of plagioclase+quartz to pyroxene+garnet in the chosen level. The mafic 212 boudin is enriched in Ca, Fe and Mg and depleted in Si and Na with respect to the 213 mafic and intermediate layers (similar to the PI-rich HP granulite of sample A1553) 214 within the banded HP granulite sequence. As for trace elements, the four samples 215 have similar trends, with the mafic boudin (A1554) being lower in most elements. 216 Normalized patters (Fig. 5) are around 10 times primitive mantle for the HREE and 217 rise to 100 times for Rb and Ba, with Ce reaching 200-500 times primitive mantle. A 218 marked positive anomaly for Pb and K, and negative anomaly for Th and Ti are 219 present.

Relative to each other, the intermediate layer is the richest in incompatible elements and thus likely to be more similar to a melt composition. The mafic boudin is enriched in compatible elements such as Cr and Ni, and contains a similar amount of HREE as the intermediate layer.

224

5. Zircon U-Pb geochronology and trace element geochemistry

226 The Pl-rich HP granulite (A1553) contains abundant zircon crystals which are 227 clear, colourless to light pink and generally euhedral, with dimension varying from 228 100 to 500 µm in length. The zircon internal structure is characterised by large cores 229 containing composite growth domains. Microstructurally, the youngest components in 230 the cores are large areas with broad-banded oscillatory-zoning (Fig. 6). Cores with 231 low CL emission and patchy zoning, likely to indicate metamictization, are also 232 present. The zircon cores commonly contain sealed fractures or deformation 233 structures as described in mylonitic rocks (Kaczmarek et al., 2008; Reddy et al., 234 2006). Thin, unzoned rims are present in numerous crystals but only occasionally 235 reach a size that is suitable for SHRIMP analysis (20µm). 236 SHRIMP analyses were concentrated on the texturally younger parts of the cores 237 and on the unzoned rims. Core apparent ages scatter along *Concordia* between ~500 238 and 350 Ma with a consistent group of the five oldest analyses defining a Concordia 239 age of 486±7 Ma (Fig. 7). 240 The 18 analyses on rims yielded Caboniferous ages (Table 2) that, with the 241 exception of two, define a *Concordia* age of 340.7±4.2 Ma (Fig. 7). Two analyses are 242 statistically younger and are suspected of Pb loss. Notably, the youngest analysis on 243 a zircon core is within error of the age of the rims. 244 Core and rim domains are distinct on the basis of their chemical composition 245 (Tables 2 and 3). There is significant overlapping in U contents between the two

246 domains, but the cores are generally richer in Th, resulting in higher Th/U (>0.3).

247 Cores are richer in REE and have a strong enrichment in HREE, whereas the rims

have a generally flat HREE pattern at 10-100 times chondrite (Fig. 8). Rims also have

a small negative or absent Eu anomaly, whereas the cores have a marked negative

250 Eu anomaly (Eu/Eu* < 0.4).

251 Ti contents in the cores vary between 5 and 17 ppm (Table 3), which translate in 252 temperatures between 690-790 °C (Watson and Harrison, 2005). Zircon rims show 253 restricted variations in Ti content with respective temperatures of 710-770 °C. Such 254 temperatures are assuming rutile to be the buffering Ti phase, whereas T would be 255 \sim 50 °C higher if zircon grew in a titanite or ilmenite-bearing assemblage. In this 256 sample, rutile is the stable Ti-phase during HP metamorphism (stage A-B of Fig. 4, 257 Ferrando et al., 2008), and reacted to form titanite and then ilmenite during 258 decompression (stage C-D of Fig. 4, Ferrando et al., 2008). 259 The zircon cores in this Pl-rich HP granulite contain inclusions of plagioclase, 260 biotite, amphibole with composition similar to that found in basic layers (Ferrando et 261 al., 2008), and chlorite, phengite, apatite, guartz, rare rutile and K-feldspar. 262 However, these mineral inclusions are only contained in the cores and commonly 263 along fractures (Fig. 6). We interpret the inclusion assemblages as the combination 264 of inherited and secondary minerals that offer no insight on the condition of zircon 265 crystallization. Notably, no inclusion is contained in the \sim 340 Ma rims. 266

The Pl-poor HP granulite is relatively poor in zircon compared to its Pl-rich 267 268 counterpart. The zircons are clear, pink to light red in colour, and commonly have a 269 rounded shape. Their size is comparable to the other sample with diameters of 100-270 500 µm. The internal structure is somewhat simpler, with most grains having 271 concentric broad-banded and sector zoning (Fig. 6). Fractures and deformation 272 features are present in about 50% of the grains. In several grains, thin bright rims 273 surround the cores, but only in a few cases their size allowed location of the ion 274 beam.

The zircon cores with sector zoning yielded ages between ~346 and 320 Ma, with three rim analyses returning ages in the middle of this range. Cumulatively these

analyses define a Concordia age of 336.3 ± 4.1 Ma, excluding two statistically younger analyses (Fig. 7). Out of the few texturally older cores, which have a different CL zoning pattern, a single one was analysed and yielded a discordant 206 Pb/ 238 U age of 378 ± 6 Ma (Table 2).

The zircons contain amounts of U variable over more than an order of magnitude, with the rims having the lowest concentrations. Th is generally low and Th/U <0.15. For the cores, REE patterns are enriched in HREE with respect to the LREE and show a moderate negative Eu anomaly (0.5-0.6, Fig. 8). In comparison, the zircon rims are distinguished because they have the lowest REE concentrations, limited HREE

287 Ti contents are between 6 and 11 ppm, with no measurable difference between

cores and rims (Table 3). Ti-in-zircon thermometry (Watson and Harrison, 2005)

returns *T* of 700-750°C. This is again assuming formation in a rutile-bearing

enrichment and a weak negative Eu anomaly (0.7-0.9).

assemblage with $T \sim 50^{\circ}$ C higher if zircon grew during decompression when ilmenite

291 was likely to be stable (Ferrando et al., 2008). Since the sample contains only rare

292 quartz the activity of SiO_2 may have been <1. Lower SiO_2 activity will shift calculated

293 temperatures toward lower values (N. Tailby, personal communication).

294 Mineral inclusions of biotite and plagioclase are present in zircon grains that have 295 disturbed CL patterns with patchy alteration and fractures, or in cores of possible 296 inherited nature. This suggests that the inclusions are mainly secondary or inherited 297 and thus do not offer significant information for the age interpretation.

298

286

6. Discussion

6.1. Chemistry and age of the protolith

301 The bulk rock chemistry of the different layers varies significantly, indicating that 302 the layers either represent different stages of melt evolution or are due to cumulus. 303 The relative enrichment in the basic boudin of compatible elements such as Cr and 304 Ni, despite similar enrichment in incompatible elements, indicates that it is likely to 305 be a cumulate rather than a more primitive melt. Similarly, with respect to the Pl-306 poor boudin, the PI-rich layer is enriched in Si and Sr, but relatively low in 307 incompatible elements with respect to the intermediate layer, suggesting that its 308 protolith was a plagioclase cumulate rather than a more evolved melt. The 309 intermediate layer is taken as most similar to the initial liquid composition because of 310 its enrichment in incompatible elements and moderate Si content. The protolith of 311 this layer was likely to be between gabbro, for its Si content, and diorite for its 312 relatively high Al and low Mg, Fe and Ca. When compared to continental crust and 313 arc magmas (Fig. 5) the intermediate layer shares several trace element features 314 (strong Cs enrichment, Pb and K positive anomaly, Nb and Ta depletion, Zr and Hf 315 relative enrichment and Ti negative anomaly) with the continental crust. 316 In summary, the Frisson Lakes mafic sequence is likely derived from a mafic, 317 layered intrusion with Pl-rich and Pl-poor (Cpx-rich) cumulus layers. The parental 318 magma was gabbroic to dioritic in composition with a strong crustal component. The 319 presence of inherited magmatic zircon is in line with a mafic parental magma with

320 crustal affinity.

321

The zircon cores offer some insight into the age of the protolith of the H*P* granulites. The texturally younger growth zone in the zircon cores shows oscillatory zoning, it has uniform chemical composition (Fig. 8) but variable U-Pb ages. These domains have signs of deformation and intense fracturing (Fig. 6), which have been previously demonstrated to favour Pb loss (e.g. Reddy et al., 1999). During the

327 intense deformation, Pb could have easily diffused out of the crystal, whereas trace 328 elements, which are more compatible in zircon, were retained. This decoupling of Pb 329 and other elements has been extensively documented, for example, in inherited 330 zircons within ultra-HP rocks of the Dabie-Sulu terrain (Xia et al., 2009). The 331 relatively high Th/U ratio, the steep HREE pattern and the marked negative Eu-332 anomaly measured in the zircon cores are common features of magmatic zircons 333 (Hoskin and Schaltegger, 2003; Rubatto, 2002). We thus suggest that the texturally 334 younger, and volumetrically dominant part of the zircon cores formed during 335 magmatic crystallization of the protolith. The U-Pb system of these cores was partly 336 reset during the intense deformation associated with Variscan metamorphism (see 337 Section 6.2.). In such a scenario, the minimum age for the crystallization of the 338 magmatic zircon cores is constrained by the oldest ages measured in such domains, 339 i.e. 486±7 Ma. The presence of metamorphic mineral inclusions in the zircon cores 340 (e.g. rutile) apparently contradicts this conclusion. However, the fact that such 341 inclusions occur mainly along fractures and deformation features makes their 342 petrological significance dubious.

343 Mafic magmas of Cambro-Ordovician age are reported across the External 344 Crystalline Massifs. The most prominent in size is the Chamrousse ophiolite 345 (Belledonne Massif, \sim 150 km NNW of the Argentera Massif), which formed at 496±6 346 Ma in a back-arc basin (Ménot et al., 1988). The Chamrousse ophiolite is largely 347 composed of ocean floor tholeiites that are only marginally enriched in LREE and lack 348 the prominent crustal signature seen in the Frisson Lakes rocks (Bodinier et al., 349 1982). Other Ordovician mafic rocks are disseminated within the External Crystalline 350 Massifs (Guillot and Menot, 2009; Ménot and Paquette, 1993; Rubatto et al., 2001), 351 occur as relatively small bodies within the crustal basement, are often associated 352 with Si-rich magmas, and are generally overprinted by high-grade metamorphism.

353 Their age varies between ~480 and 460 Ma and, similarly to the Frisson Lakes mafic 354 sequence, they show high degree of crustal contamination. This Ordovician bimodal 355 magmatism related to rifting is also known in the Massif Central (e.g. Pin and Marini, 356 1993) and is widespread in the Bohemian Massif, where it appears to be somewhat 357 older (~500 Ma, e.g. Turniak et al., 2000). In our opinion, the chemical features of 358 the Frisson Lakes mafic sequence can be better reconciled with those of this 359 Ordovician bimodal magmatism (Bodinier et al., 1982; Guillot and Menot, 2009), of 360 which the Frisson Lakes sequence would represent an early stage.

361

6.2. Age and conditions of metamorphism

363 Zircon rims in the PI-rich HP granulite and sector zoned domains in the PI-poor HP 364 granulite yielded indistinguishable Carboniferous ages at ~340 Ma (340.7±4.2 and 365 336.3 \pm 4.1 Ma, respectively). The low Th/U of the zircon rims in the PI-rich HP 366 granulite is a common feature of metamorphic zircon and can be ascribed to the 367 formation of a Th-rich phase such as monazite, which is abundant in this sample. 368 The HREE depletion in the zircon rims is in line with formation, before or during 369 zircon crystallization, of metamorphic garnet that sequestrated HREE from the 370 reactive rock bulk (Rubatto, 2002). The zircon rims lack a significant negative Eu 371 anomaly, which is also absent in the other metamorphic minerals such as omphacite, 372 garnet and plagioclase (own unpublished data). Ti-in zircon thermometry indicates 373 temperatures of at least 700-770°C, which are within that reported for the HP peak (735±15 °C, Ferrando et al., 2008) but generally higher than those of the first 374 375 retrogression stage (709±2°C, Ferrando et al., 2008). All these chemical features are 376 interpreted to indicate zircon rim formation during HP granulite-facies 377 metamorphism.

378 Notably, the calculated Y and HREE partitioning between the ~340 zircon rims 379 and garnet, which has little zoning, returns values far lower than any published 380 equilibrium partitioning (Rubatto and Hermann, 2007). This suggests that the dated 381 zircon rims, despite having formed in an environment depleted in HREE by garnet 382 growth, are not in chemical equilibrium with the garnet now present in the rock. In 383 fact, textural relationships and chemical data (Ferrando et al., 2008) indicate that, 384 particularly in the PI-rich granulite, garnet completely re-equilibrated during mylonitic 385 deformation (stage C in Fig. 4). Thus, the trace element disequilibrium between 386 zircon and mylonitic garnet supports zircon formation before the mylonitic overprint. 387 This example demands caution when applying partition coefficients in poorly 388 equilibrated and complex assemblages.

389 The zircons from the PI-poor HP granulite A1554 have sector zoning that is not 390 particularly diagnostic: similar zoning has been described for granulite-facies zircon 391 (e.g. Vavra et al., 1996) as well as for gabbroic zircon (e.g. Rubatto and Gebauer, 392 2000). Despite their low Th/U, the REE patterns of the zircon from the Pl-poor HP 393 granulite resemble that of the magmatic zircon cores in the Pl-rich HP granulite (e.g. 394 HREE enrichment). HREE depletion would be expected in metamorphic zircon formed 395 in such a garnet-rich rock. Garnet in the sample has, in fact, a flat HREE pattern at 396 50-100 chondrite (own unpublished data). The few unzoned zircon rims in the Pl-397 poor HP granulite that could be analysed show a distinctly lower HREE content, but 398 their age is undistinguishable, at this level of precision, from that of the cores. This 399 leads to the suggestion that the lack of HREE depletion in most of the metamorphic 400 zircons may be explained by delay in the growth of garnet in this rock. The 401 undistinguishable age between the zircon cores in the Pl-poor HP granulite and the 402 metamorphic zircon rims in the PI-rich HP granulite forces a common interpretation,

403 i.e. they are both metamorphic despite the inconclusive features of the PI-poor HP404 granulite zircons.

405 In the four-stage evolution reconstructed by Ferrando et al. (2008) for the Frisson 406 Lakes HP granulites (Fig. 4), it is concluded that the zircon rims formed before stage 407 C (mylonitisation at 665±15°C and 0.85±0.15 GPa). This conclusion is based on the 408 intense deformation recorded by zircons and on the temperature given by the Ti-in-409 zircon thermometry for the PI-rich sample. The regional anatexis post-dates both the 410 mylonitic stage and the intrusion of monzonites dated at 332±3 Ma, which 411 underwent partial melting (Rubatto et al., 2001). This evolution is testified by the 412 discordant relationships between the mylonitic foliation of the HP granulite and the 413 hosting migmatitic granitoid gneiss, which preserves relicts of igneous fabric. This 414 leaves a window at ~800-700°C and ~1.4-1.0 GPa between the metamorphic peak 415 and the first decompression stage for the growth of the \sim 340 Ma zircon (Fig. 4). 416 The Frisson Lakes HP granulites essentially underwent the same metamorphic 417 evolution as the Meris eclogite (Ferrando et al., 2008), which recorded a different 418 assemblage simply because of its composition. We can therefore infer that ~340 Ma 419 also dates the metamorphic peak or early decompression in the eclogite. This 420 represents the first geochronological data on HP metamorphism in the Argentera 421 Massif and in the External Crystalline Massifs.

422

423 **6.3. Carboniferous HP metamorphism in the Variscan belt**

There are few and weak constraints on the age on H*P* metamorphism across the European Variscan basement, particularly in its western part. This is largely due to the poor preservation of H*P* assemblages, which were extensively retrogressed during late-Variscan H*T* metamorphism and anatexis (von Raumer et al., 2009). The pioneering zircon isotope-dilution TIMS work of Paquette et al. (1989) analysed mafic

429 rocks with variably preserved HP assemblages from eclogites (Belledonne and 430 Aiguilles Rouges Massifs) to garnet amphibolites (Argentera Massif). They obtained 431 mainly discordant data, whose upper and lower intercepts are of difficult 432 interpretation. In most samples, no age constraints on the HP metamorphism were 433 obtained, but for the Argentera Massif a lower intercept of 424±4 Ma from an 434 amphibolite was proposed as the age of HP metamorphism. Notably, a second mafic 435 rock from the same area returned an upper intercept at ~350 Ma with a meaningless 436 lower intercept.

In Sardinia, at the southern end of the Variscan belt, a recent detailed study of zircon from retrogressed eclogites failed to constrain the age of H*P* metamorphism, but proposed an age of 352 ± 3 Ma for amphibolite-facies decompression after H*P* metamorphism (Giacomini et al., 2005). An age of ~400 Ma has been speculated by many authors for the Sardinia eclogites on the basis of poorly constrained zircon data, whose relationship to H*P* metamorphism has, however, not been proven (Cortesogno et al., 2004; Palmeri et al., 2004).

444 No other modern geochronology of eclogites has been carried out on the 445 Southern European Variscan belt and the age of Variscan eclogites remains unclear 446 in the western part of the Variscan orogeny. In the central Variscan, a hypothetical 447 460-470 Ma HP metamorphism was postulated on the basis of U-Pb and Sm-Nd 448 geochronology (Gebauer, 1993) in the Gotthard Massif. Further to the east, Sm-Nd 449 geochronology of eclogitic assemblages from the Eastern Alps returned younger ages 450 around 360-350 Ma for the Ötztal eclogites (Miller and Thöni, 1995) and ~330 Ma for 451 the HP rocks in the Ulten zone (Tumiati et al., 2003). Such ages are closer to the 452 more robust constraints on the age of Variscan HP metamorphism, which comes 453 from the Bohemian Massif, including the Polish Sudetes (Bröcker et al., 2009; Kröner 454 et al., 2000; Schulmann et al., 2005). SHRIMP U-Pb analyses on zircon within an HP

paragenesis returned ages of ~340 Ma (Kröner et al., 2000). This age was later
confirmed with Pb-evaporation analysis of zircon from an HP granulite (Schulmann et
al., 2005) and recent SHRIMP dating of zircon within a mafic eclogite of the Sudetes
(Bröcker et al., 2009).

459

460 From regional reviews (Franke and Stein, 2000; O'Brien, 2000) it appears that, 461 across the dismantled European Variscan orogen and excluding the anomalous data 462 from the Gotthard Massif, there are relicts of two eclogitic events: an early one in the 463 Devonian (~400 Ma) and a later one in the Carboniferous ~350-340 Ma. O'Brien 464 (2000) concluded that the Devonian HP rocks are remnants of medium-temperatures 465 (eclogites and blueschists) subduction of an oceanic sequence, whose products were 466 then already exhumed by Late Devonian. A later subduction cycle involved different, 467 mostly continental rock associations that reached higher temperatures (900-1000°C) 468 and produced extensive felsic granulites (Tajcmanova et al., 2006). For this second 469 Variscan subduction, O'Brien (2000) reported a likely age of ~340 Ma, based on data 470 from the Bohemian Massif. Subduction was followed by rapid exhumation and cross 471 cutting granite intrusions at 315–325 Ma, both contributing to the high thermal 472 gradient that led to widespread Variscan Barrovian metamorphism dated between 473 340 and 310 Ma in different regions (see below).

The continental nature of the protolith, the metamorphic grade, the rapid decompression and age of the Frisson Lakes H*P* granulites ascribe these rocks to the second subduction cycle. To our knowledge there is no relict of the Devonian, medium temperature eclogites in the Argentera Massif or any of the External Crystalline Massifs.

479

480 **6.4.** Comparison with the Bohemian Massif and implications for

481 tectonic style

These new results combined with previous data constrain the evolution of the Gesso-Stura Terrain within the Argentera Massif before and during the Variscan orogeny. Such evolution is likely to be largely comparable to that of other External Crystalline Massifs, which show similar lithostratigraphy and metamorphic assemblages (von Raumer et al., 2009).

487 Bimodal magmatism occurred in Ordovician to Silurian times with intrusion of 488 dacite and gabbros (Rubatto et al., 2001) in an already metamorphosed basement. 489 The crustal contamination in the Frisson Lakes mafic sequence supports an 490 extensional setting in agreement with what proposed for the External Crystalline 491 Massifs (Guillot and Menot, 2009; Ménot and Paquette, 1993). HP metamorphism at 492 the granulite-eclogite facies boundary occurred during the Carboniferous (~340-336 493 Ma) at conditions that could be compatible with subduction during continental 494 collision (e.g. O'Brien, 2000). The HP event was followed by limited magmatism of 495 likely extensional nature (intrusion of K-rich monzonites, Rubatto et al., 2001), with 496 extension being a likely cause of fast exhumation of the HP rocks. Shortly after, the 497 Massif underwent pervasive LP-HT metamorphism and anatexis (330-310 Ma Rubatto 498 et al., 2001). Carboniferous HP metamorphism in the Argentera Massif occurred only 499 some 10-20 Ma before the widespread migmatisation documented not only in the 500 Massif but also elsewhere in the Variscan basement of Western Europe. The tight 501 succession of HP and LP-HT metamorphism suggests that the two stages are part of 502 the same metamorphic cycle where intense melting occurred upon decompression and advective heat transfer. The final exhumation of the Massif is marked by the 503 504 unconformable deposition of Stephanian sediments (299-298 Ma, Faure-Muret, 505 1955).

507 In order to investigate the evolution of the Variscan orogen on a larger scale, a 508 comparison is attempted here with the Bohemian Massif, which is one of the largest 509 remnants of Variscan basement and occupies a strategic position at the eastern end 510 of Variscan Europe. This comparison is aided by the detailed tectonic and 511 geochronological constraints available for the Bohemian Massif, in comparison to 512 other portions of Variscan Europe.

513 The evolution of the Argentera Massif is similar, but not directly comparable in 514 age and metamorphic grade, to the evolution proposed for the Bohemian 515 counterpart (Kröner et al., 2000; Schulmann et al., 2009; Schulmann et al., 2005; 516 Tajcmanová et al., 2006). A significant difference is the presence in the Bohemian 517 Massif of medium temperature eclogites of presumably older age (~400-390 Ma) 518 that are taken to constrain Devonian subduction (see a review in O'Brien, 2000; 519 Schulmann et al., 2009). No evidence of such assemblages is present in the western 520 part of the Variscan orogen. The Sardinian eclogite of presumed ~400 Ma age 521 followed a high temperature path more similar to the Argentera HP granulite rocks. 522 Carboniferous collision in the Bohemian Massif produced thick continental roots. 523 Within this scenario, the Carboniferous HP assemblages in the felsic granulites 524 recorded higher metamorphic conditions of >15 kbar and >850-900 °C (Kröner et 525 al., 2000; Tajcmanová et al., 2006), which are not reported for the western Variscan 526 orogen. Two different geotherms have been proposed to explain contrasting, but 527 coeval metamorphic conditions recorded by felsic granulites and mafic eclogites in the Bohemian Massif, (e.g. Konopásek and Schulmann, 2005; Štípská et al., 2006). 528 529 On the contrary, the Frisson Lakes HP-granulites and the Meris mafic eclogite within 530 the Argentera Massif record similar peak and exhumation conditions, as discussed in 531 detail by Ferrando et al. (2008). To our knowledge, no such duality of Carboniferous

506

HP metamorphism has been documented in other Variscan massifs. For the
Bohemian Massif, HP and ultra-HP metamorphism are generally attributed to
subduction, but an alternative model of accretionary prism above an underthrusted
continental crust has been proposed for the HP granulites (e.g. Schulmann and
Gayer, 2000). This latter model is supported by the high geothermal gradient and
rapid progression to anatexis (Stípská et al., 2006). Such alternative settings remain
unexplored for the Argentera Massif.

A significant difference between the western and eastern Variscan is the age of

540 anatexis. In the south-east anatexis must be younger than ~330 Ma (Rubatto et al.,

541 2001) and likely between 320 and 310 Ma (Demoux et al., 2008; Rubatto et al.,

542 2001), and therefore delayed of 10-20 Ma after HP metamorphism. In the Bohemian

543 Massif, this time gap is not present as migmatisation occurred at ~340 Ma (e.g.

544 Anczkiewicz et al., 2007; Bröcker et al., 2009; Schulmann et al., 2005) during fast

545 decompression of the HP rock.

546 The differences between the eastern and western Variscan, which may be partly 547 attributed to poor preservation and limited data for the western units, are

548 nevertheless significant and attest to variation in timing and metamorphic conditions

along the axis of the vast Variscan orogen. Despite such differences, the eastern and

550 western portions of Variscan Europe show many intriguing similarities in their *P-T*-

time evolution (cf. *P-T*-time in this work and Tajcmanová et al., 2006).

552 The evolution proposed here for the Argentera Massif (Fig. 4) does not support an

Andean-style model as proposed by Schulmann et al. (2009) for the Bohemian

554 Massif. The major difference with the Andean model being the lack of both low-

- 555 medium temperature high-pressure rocks, and significant arc-related magmatism
- 556 during or after Carboniferous subduction. In the Argentera Massif, Carboniferous
- alkaline magmas are small in volume and likely related to extension (monzonite at

332 Ma, Rubatto et al., 2001), with the possible exclusion of the mafics in the

559 Bousset-Valmasque Complex, which age is however unconstrained.

The new data also support the hypothesis that the overall evolution of the Variscan belt resembles that of the Himalayan chain. Whereas this comparison has been proposed for the eastern Variscan (Massonne and O'Brien, 2003; O'Brien, 2000; Stípská et al., 2006), with the new data presented here it is possible to extend it to the western Variscan. Similarities between the Variscan and the Himalayan orogenies include the conditions of H*P* granulite-facies metamorphism, and the rapid succession (within <20 Ma) of H*P* conditions, fast exhumation and widespread

567 anatexis.

568

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777 FIGURES and TABLES CAPTIONS

778

779 Table 1. XRF bulk rock chemical analyses.

780 Table 2. SHRIMP U-Pb analyses of zircons.

781 Table 3. LA-ICPMS analyses of zircons.

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105	
784	Fig. 1. a) Map of the European Variscan orogen (modified from O'Brien, 2000;
785	Stampfli et al., 2002; von Raumer and Bussy, 2004). C: Corsica; MT: Maures-
786	Tanneron Massif; RH: Rheno-Hercynian; S: Sardinia; SW: Schwarzwald; V: Vosges.
787	The Argentera Massif is shown in the box. b) Geological sketch of the Argentera
788	Massif. The samples were collected at Frisson Lakes, indicated with a star.
789	
790	Fig. 2. Geological sketch-map of the Frisson Lakes area (modified after
791	Colombo et al., 1994).
792	
793	Fig. 3. a) Field occurrence of the Frisson Lakes mafic sequence with alternating
794	layers of Pl-poor and Pl-rich (similar to sample A1553) HP granulites. Sample A1554
795	correspond to the dark boudin. b) Scan of a thin section of PI-rich HP granulite
796	A1553 illustrating the mylonitic texture with relict garnet porphyroclasts. Field of
797	view: 2.0x1.75 cm. c) Scan of a thin section of Pl-poor HP granulite (sample A1554)
798	with a cataclastic texture defined by large garnet crystals within a matrix mainly
799	composed of clinopyroxene, amphibole and minor plagioclase. Field of view: 2.3x1.9
800	cm.

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Fig. 4. *P-T*-time evolution of the Gesso-Stura Terrain. Phase relations for Al₂SiO₅ are after Holdaway & Mukhopadhyay (1993) and the wet granite solidus is after Aranovich & Newton (Aranovich and Newton, 1996). *P-T* conditions for stages A-D (ellipses) are from Ferrando et al. (2008) and for the anatexis (cross) are from Bierbrauer (1995). Geochronological data are from this work, (1) Rubatto et al. (2001) and (2) Faure-Muret (1955).

808

Fig. 5. Primitive mantle normalized diagram of bulk rock chemical
compositions. Normalizing values according to McDonough and Sun (1995). Mariana
Arc composition from Kelemen et al. (2004) and upper crust composition from
Rudnick and Gao (2004).

813

Fig. 6. Cathodoluminescence images of zircon crystals from the two samples.
Dotted circles indicate LA-ICP-MS analyses for trace elements, and small circles
indicate SHRIMP analyses for U-Pb. For each SHRIMP analysis, ages are given in
Ma±1 sigma. Scale bar represents 100 µm. Note the large inherited cores in the Plrich HP granulite A1553, which yield scattering ages. The linear features cutting
across the crystal are due to deformation. See text for discussion.

Fig. 7. *Concordia* plots for SHRIMP U-Pb analyses. Data were corrected for common Pb. Ellipses are 2 sigma errors. Dotted ellipses are excluded from the *Concordia* age calculation. See text for discussion.

824

Fig. 8. Chondrite normalized trace element pattern of zircons from the dated samples (A1553 and A1554). Normalizing values according to McDonough and Sun (1995). See text for discussion.



Figure 1.















TABLE 1. XRF bulk rock analys

		A1553a	A1553c	A1553b	A1554
			intermediate		
	wt %	felsic layer	layer	basic layer	mafic boudin
SiO ₂		56.10	51.70	49.50	45.80
AI_2O_3		17.95	18.25	16.35	16.45
FeO		5.13	6.62	8.84	8.31
Fe_2O_3		1.30	1.64	1.87	3.26
CaO		5.89	6.69	7.48	10.25
MgO		3.95	4.94	5.86	9.43
Na_2O		5.88	4.50	3.39	2.48
K ₂ O		1.02	1.29	0.80	0.82
Cr_2O_3		0.01	0.02	0.02	0.04
TiO ₂		0.81	1.29	1.62	1.21
MnO		0.10	0.13	0.19	0.19
P_2O_5		0.16	0.32	0.33	0.12
SrO		0.05	0.06	0.05	0.02
BaO		0.04	0.04	0.02	0.02
LOI		1.10	1.67	1.45	1.32
Total		100.00	99.90	98.80	100.50
Mg#		0.435	0.427	0.399	0.532
A	ppm	. 4	. 4	. 4	. 4
Ag Bo		<1 241	<1 222	<1 219	<1 147 5
Ба Се		25.2	43.1	33.6	147.5
Co		20.0	26.3	35.4	46.5
Cr		120	120	150	290
Cs		4.59	8.05	7.50	9.48
Cu		23.0	29.0	39.0	43.0
Dy		3.48	5.17	6.64	5.06
Er		2.30	3.14	4.14	3.14
Eu		1.00	1.50	1.62	1.30
Gd		3 32	5 58	5 68	4 36
Hf		3.00	6.40	4.30	2.40
Но		0.69	1.04	1.34	1.02
La		11.2	19.8	15.1	4.3
Lu		0.35	0.44	0.54	0.41
Мо		<2	<2	<2	<2
ND		8.40	11.6	10.8	4.90
Nu Ni		13.9 41 0	23.2 47 0	20.0 54.0	11.0
Pb		17.0	21.0	12.0	7.0
Pr		3.01	5.24	4.23	1.88
Rb		31.7	45.8	33.2	27.5
Sm		3.29	5.54	5.09	3.72
Sn		2.0	4.0	3.0	3.0
Sr		440	486	399	163
Th		0.0	0.7	0.7	0.3
Th		0.55	1.9	0.92	0.18
TI		< 0.5	< 0.5	< 0.5	< 0.5
Tm		0.30	0.44	0.55	0.43
U		0.57	0.85	0.83	0.12
V		116	160	222	243
W		1.0	1.0	2.0	2.0
r Vh		22.0	31.3 2.06	38.1	29.0
7n		2.13	112	129	122
Zr		119	244	172	77

Table 2. SHRIMP U-Pb analyses of zircons.

Label C. domain Pb, %b U(ppn) Th (ppn)							206ph / 23811					% error		% error	error	
False prolite (A1553) Im 0.66 47 9 0.23 319.5 1.1 0.00677 0.3695 3.12 0.0528 1.14 0.358 A1553-1.1 mm 0.00 41 54 0.553 3.22 0.0528 3.10 0.5258 1.31 0.0528 1.30 0.5258 1.31 0.0531 1.41 0.354 A1553-16.1 mm 0.01 1.21 0.00 333.5 6.4 0.03310 0.3793 6.74 0.0310 1.72 0.335 A1553-16.1 mm 0.01 221 1.1 0.04 334.3 3.3 0.63322 0.00054 0.3660 2.09 0.65322 1.01 0.48 A1553-10.1 mm 0.01 7.4 0.05 331.4 3.3 0.63322 0.00071 0.312 2.68 0.04471 1.04 0.352 A1553-10.1 mm 0.01 7.41 0.19 331.9 7.5 0.05414 0.00071 0.312 2	Label	CL domain	Pb _c %	U (ppm)	Th (ppm)	Th/U	Age	±1 sigma	²⁰⁶ Pb/ ²³⁸ U	±1 sigma	²⁰⁷ Pb/ ²³⁵ U	(1 sigma)	²⁰⁶ Pb/ ²³⁸ U	(1 sigma)	correlation	
ALSS-11 nm 0.06 470 9 0.02 319.5 2.8 0.05081 0.3945 1.70 0.05081 0.099 0.528 ALSS-11 nm 0.11 1.11 5 0.058 327.7 4.2 0.05286 0.3945 3.12 0.0528 1.08 0.0528 ALSS-15.1 nm 0.10 121 7 0.06 334.3 3.7 0.05322 0.00606 0.3793 3.12 0.05322 1.01 0.436 ALSS-15.1 nm 0.10 122 7 0.06 334.3 3.7 0.05322 0.00650 0.3793 3.12 0.05322 1.01 0.436 ALSS-16.1 nm 0.00 72 4.4 0.03 3.33 0.05322 0.00651 0.4362 3.62 0.0517 0.93 0.34 ALSS-12.1 nm 0.15 76 1.4 0.16 334.9 4.5 0.05449 0.00073 0.4275 4.34 0.05449 0.0275 4.34 0.05449 0.0073 0.4275 4.34 0.05449 0.0274 <td>Felsic gran</td> <td>ulite (A1553)</td> <td></td>	Felsic gran	ulite (A1553)														
ALSS-11. mm 0.00 94 54 0.59 327.9 4.1 0.05236 0.00657 0.9453 3.12 0.05236 1.14 0.366 ALSS-11. mm 0.11 11 5 0.53 333.7 4.8 0.05236 0.00078 0.4447 4.31 0.05398 1.38 0.05392 1.12 0.05322 1.12 0.05322 1.12 0.05322 1.12 0.05322 1.12 0.05322 1.12 0.05322 1.12 0.05322 1.01 0.466 ALSS-10.1 mm 0.00 7.2 44 0.43 336.7 4.8 0.00532 0.00054 0.4607 0.467 0.4647 1.44 0.44 3.43 3.0 0.05427 0.0056 0.5912 1.80 0.05407 0.466 3.55 3.51 0.05474 0.00561 0.4115 1.94 0.4063 3.55 1.53 1.53 1.53 1.53 0.05474 0.00510 0.05474 0.05474 0.05474 0.404 0.355 1.55 3.55 1.55 0.5517 0.05648 0.140	A1553-9.1	rim	0.06	470	9	0.02	319.5	2.8	0.05081	0.00046	0.3699	1.70	0.05081	0.90	0.526	
ALSS-11.1 nm 0.11 111 5 0.05 33.2.7 4.2 0.05296 0.00096 0.9131 3.1.0 0.05296 1.3.3 0.419 ALSS-11.1 nm light 0.13 31 19 0.36 33.3 6.4 0.05396 0.0016 0.9173 6.7.4 0.05319 1.72 0.355 ALSS-10.1 nm 0.01 22 11 0.06 33.4 3.4 0.05322 0.00078 0.0603 3.6.2 0.05562 1.12 0.466 ALSS-10.1 nm 0.00 40 33.4 3.4 0.05547 0.012 1.80 0.05547 0.19 0.5647 0.91 0.568 ALSS-13.1 nm 0.00 114 0.04 33.9 3.5 0.05479 0.0112 1.80 0.05497 0.1912 2.86 0.05497 0.191 0.552 ALSS-13.1 nm 0.00 111 0.05439 0.00439 0.00439 1.01 0.552 1.11 0.05439 0.05439 0.0044 0.419 3.45 0.453 0.00143 <td>A1553-7.1</td> <td>rim</td> <td>0.00</td> <td>94</td> <td>54</td> <td>0.59</td> <td>327.9</td> <td>4.1</td> <td>0.05219</td> <td>0.00067</td> <td>0.3945</td> <td>3.12</td> <td>0.05219</td> <td>1.14</td> <td>0.366</td>	A1553-7.1	rim	0.00	94	54	0.59	327.9	4.1	0.05219	0.00067	0.3945	3.12	0.05219	1.14	0.366	
ALSS-11.1 mm light 0.13 54 19 0.36 333.5 4.8 0.05309 0.0078 0.4047 4.31 0.05309 1.38 0.319 ALSS-15.1 mm 0.10 121 7 0.06 334.3 3.7 0.05320 0.00780 0.779 3.12 0.05322 1.12 0.359 ALSS-15.1 mm 0.00 7.2 4.4 0.64 336.7 4.3 0.05420 0.00780 0.493 3.62 0.05402 0.44 0.359 ALSS-13.1 mm 0.00 178 1.4 0.44 3.93.4 3.0 0.05407 0.0493 0.05407 0.44 0.39 ALSS-12.1 mm 0.15 7.6 1.4 0.49 3.99 4.5 0.05410 0.00073 0.4275 4.34 0.05410 1.00 0.319 0.3552 1.4 0.05439 1.00 0.05439 1.00 0.4116 1.45 1.45 0.4553 1.1 0.5552 0.05514 0.00073 0.416 1.45 0.466 1.4555.4 1.0552 0.05514	A1553-1.1	rim	0.11	111	5	0.05	332.7	4.2	0.05296	0.00069	0.3913	3.10	0.05296	1.30	0.419	
ALSS-16.1 imin light 0.95 31 18 0.60 333.5 6.4 0.0512 0.00105 0.3791 6.74 0.05320 1.12 0.05322 ALSS-16.1 irm 0.01 22 11 0.06 334.3 3.7 0.05322 0.0054 0.3860 2.09 0.05322 1.12 0.385 ALSS-16.1 irm 0.01 222 10 0.04 334.3 3.1 0.05322 0.0054 0.3860 2.09 0.05407 1.04 0.386 ALSS-16.1 irm 0.09 154 7 0.05 339.5 3.5 0.05414 0.00077 0.3272 4.34 0.05439 1.01 0.52 ALSS-14.1 irm 0.09 341.4 3.7 0.05481 0.00077 0.3252 7.14 0.05491 1.01 0.5494 1.054 0.551 0.37646 0.111 0.05491 1.424 0.174 ALSS-13.1 irm 0.00 318 36.7 5.5 0.05517 0.00071 0.3365 3.111 0.05631 1.44 0.35	A1553-11.1	rim light	0.13	54	19	0.36	333.5	4.8	0.05309	0.00078	0.4047	4.31	0.05309	1.38	0.319	
A1553-16.1 irim 0.10 121 7 0.06 334.3 3.7 0.05322 0.00060 0.3779 3.12 0.05322 1.12 0.438 A1553-10.1 irim 0.00 72 44 0.63 36.7 4.8 0.05322 0.00078 0.4963 3.62 0.05402 0.1532 1.10 0.486 A1553-10.3 irim 0.00 454 1.06 0.53407 0.05407 0.04073 0.4963 3.62 0.05407 0.4963 0.65407 0.05407 0.4275 4.34 0.05414 1.30 0.599 A1553-12.1 irim 0.00 11 170 0.56 341.4 3.7 0.05439 0.00073 0.3352 7.14 0.05481 1.42 0.14 0.17 4.35 1.15 1.44 0.05499 0.00073 0.3352 7.14 0.05481 1.46 0.446 1.455 0.35510 1.04 0.44 0.4551 0.466 0.4561 0.00073 0.3352 2.15 0.05511 1.46 0.466 0.4551 0.466 0.05511 0.0560	A1553-15.1	rim light	0.95	31	18	0.60	333.5	6.4	0.05310	0.00105	0.3791	6.74	0.05310	1.72	0.255	
A1553-19.1 im 0.01 292 11 0.04 334.3 3.3 0.0532 0.03660 2.09 0.05322 1.01 0.46 A1553-10.1 im 0.00 42 44 0.63 3.62 0.00560 0.3912 1.80 0.05407 0.13 1.25 0.345 A1553-13.1 im 0.01 7 0.05 339.4 3.2 0.05407 0.01515 4.4 0.05491 1.01 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.05491 1.04 0.0551 0.00021 0.3905 2.05 0.05519 0.00529 0.3905 2.05 0.05529 0.14 2.05 0.05530 0.00074 0.3844 8.21 0.05562 0.66 0.05531 0.06060 0.05517 0.0560 0.05530 0.05510 0.05510 0.05510	A1553-16.1	rim	0.10	121	7	0.06	334.3	3.7	0.05322	0.00060	0.3779	3.12	0.05322	1.12	0.359	
ALSSS-10.1 rim 0.00 72 44 0.63 33.6.7 4.8 0.05407 0.00076 0.4663 3.6.2 0.05322 1.2 0.03322 1.2 0.0332 1.2 0.0332 1.2 0.03342 1.0 0.05407 0.00057 0.3112 1.60 0.04407 1.01 0.304 ALSSS-1.3 rim 0.00 1.04 0.034 0.05407 0.00057 0.3112 1.60 0.04407 1.04 0.304 ALSSS-1.3 rim 0.00 1.04 0.0441 0.04 1.0 0.0441 0.0441 0.0441 0.14 0.0441 0.0441 0.04541 0.0441 <	A1553-19.1	rim	0.01	292	11	0.04	334.3	3.3	0.05322	0.00054	0.3860	2.09	0.05322	1.01	0.486	
ALSS-18.3 rim 0.09 408 14 0.04 339.4 3.0 0.05407 0.00057 0.3912 1.80 0.05407 1.00 339.1 0.33 ALSS-13.2 rim 0.105 75 1.4 0.15 339.9 4.5 0.05437 0.00057 0.4275 4.34 0.05414 1.01 0.390 ALSS-12.1 rim 0.00 311 170 0.556 34.14 3.7 0.056343 0.00057 0.4151 1.4 0.05498 1.01 0.324 ALSS-12.1 rim 0.06 118 2.1 0.16 345.0 0.5510 0.00057 0.416 2.18 0.05399 1.19 0.64 0.456 ALSS-3.0.1 rim 0.01 2.41 9 0.02 345.2 0.05539 0.00057 0.416 2.18 0.05519 0.05519 1.09 0.456 ALSS-3.0.1 rim 0.06 813 18 0.02 345.7 4.1 0.05311 0.00074 0.3597 2.30 0.05681 0.00074 0.3577 2.30	A1553-10.1	rim	0.00	72	44	0.63	336.7	4.8	0.05362	0.00078	0.4063	3.62	0.05362	1.25	0.345	
AL553-1.3 rim 0.09 154 7 0.05 339.5 3.5 0.05647 0.0907 0.3912 2.68 0.05407 1.04 0.390 AL553-14.1 rim 0.00 311 170 0.56 341.4 3.7 0.05439 0.00073 0.4275 1.41 0.05431 1.01 0.522 AL553-18.1 rim 0.04 118 2.1 0.14 345.0 5.0 0.05481 0.0402 0.3965 3.11 0.05481 1.44 0.0448 AL553-2.1 rim 0.06 130 0.03 346.2 2.2 0.05517 0.00033 0.3965 2.05 0.05512 0.46 0.447 AL553-8.1 rim 0.00 31 18 0.02 345.9 2.0 0.0552 0.00044 0.3491 8.21 0.05531 0.47 0.45 0.455 AL553-8.1 core 0.33 2.37 1.03 0.45 35.7 4.1 0.0531 0.047 0.330 0.05666 0.00074 0.5337 3.00 0.05666 0.00074	A1553-18.3	rim	0.00	408	14	0.04	339.4	3.0	0.05407	0.00050	0.3912	1.80	0.05407	0.91	0.508	
A1553-12. rim 0.15 76 14 0.19 339.9 4.5 0.05414 0.00073 0.4275 4.34 0.05439 1.01 0.529 A1553-4.1 rim 2.49 86 8 0.49 344.0 4.4 0.05481 0.00061 0.4155 1.14 0.05481 1.024 0.174 A1553-12.1 rim 0.01 241 9 0.44 345.7 3.5 0.05510 0.00057 0.4116 2.18 0.05510 1.04 0.476 A1553-10.1 rim 0.66 83 18 0.42 345.3 2.5 0.05510 0.00057 0.4116 2.18 0.05510 1.04 0.476 A1553-61.1 rim 0.66 0.470 3.3 0.05562 0.00148 0.4144 2.35 0.05568 1.647 0.450 2.39 0.05610 0.99 0.39 1.45 0.456 0.00073 0.5305 2.50 0.66600 0.99 0.353 1.55 0.5305 0.0077 0.5305 2.50 0.66600 0.99 0.3535 1.535 </td <td>A1553-1.3</td> <td>rim</td> <td>0.09</td> <td>154</td> <td>7</td> <td>0.05</td> <td>339.5</td> <td>3.5</td> <td>0.05407</td> <td>0.00057</td> <td>0.3912</td> <td>2.68</td> <td>0.05407</td> <td>1.04</td> <td>0.390</td>	A1553-1.3	rim	0.09	154	7	0.05	339.5	3.5	0.05407	0.00057	0.3912	2.68	0.05407	1.04	0.390	
A1553-4.1 nim 0.00 311 170 0.66 341.4 3.7 0.05439 0.00073 0.4155 1.94 0.05439 1.01 0.522 A1553-18.1 nim 0.06 118 21 0.19 345.0 5.0 0.05548 0.00053 0.3956 3.11 0.05498 1.46 0.476 A1553-2.01 nim 0.06 305 10 0.03 344.2 3.2 0.05510 0.0416 2.18 0.05539 1.99 0.468 A1553-8.1. nim 0.00 813 18 0.42 345.7 3.5 0.05510 0.0044 0.4141 2.3 0.05562 0.00148 0.4144 2.0 0.458 1.453.42.1 0.05760 0.0108 0.4144 2.55 0.05618 0.469 1.453.43.12 0.1532 2.100 0.65218 0.99 0.453 1.453.43.12 0.1532 2.100 0.65218 0.99 0.453 1.453.43.12 0.0576 0.00074 0.5317 2.00 0.65696 0.00174 0.5317 3.03 0.06666 0.219 0.5527	A1553-21.2	rim	0.15	76	14	0.19	339.9	4.5	0.05414	0.00073	0.4275	4.34	0.05414	1.30	0.299	
A1553-81. rim 2.49 86 8 0.09 344.0 4.4 0.05481 0.00073 0.3552 7.14 0.05498 1.12 0.014 A1553-7.2.1 rim 0.00 1.241 9 0.04 345.7 3.5 0.05510 0.00057 0.4116 2.18 0.05510 1.04 0.445 A1553-12.1 rim 0.06 93 1.0 0.03 346.2 3.2 0.0517 0.00057 0.4116 2.18 0.05517 0.46 A1553-2.1 rim 0.14 93 0.46 95.7 4.5 0.05330 0.00074 0.3411 8.21 0.05508 1.96 0.440 A1553-2.2 core 0.33 2.22 110 0.6631 0.00067 0.4440 2.35 0.06600 0.99 0.3545 A1553-2.2 core 0.33 2.22 116 0.67 4.30 0.06766 0.00074 0.5337 3.03 0.06766 1.00 0.34 3.53 4.53 0.57 2.09 0.06906 1.01 0.442	A1553-4.1	rim	0.00	311	170	0.56	341.4	3.7	0.05439	0.00061	0.4115	1.94	0.05439	1.01	0.522	
A1553-2, rim 0.08 118 21 0.19 345.0 5.0 0.05498 0.00082 0.3066 3.11 0.05498 1.45 A1553-12.1 rim 0.01 241 9 0.04 345.7 3.5 0.05517 0.00053 0.3995 2.05 0.05517 0.96 0.446 A1553-3.1 rim 0.00 813 18 0.02 344.9 2.9 0.05552 0.00048 0.4107 1.33 0.05562 0.86 0.663 A1553-8.1 core 0.34 233 103 0.45 351.7 4.1 0.06031 0.00067 0.4494 2.30 0.05608 1.09 0.434 A1553-8.2 core 0.33 231 149 0.614 2.06 0.00077 0.5517 2.20 0.06606 1.00 0.444 345.7 3.5 0.09906 0.00077 0.5517 2.30 0.066906 1.00 0.444 0.454 0.454 0.454 0.454 0.454 0.454 0.454 0.454 0.454 0.454 0.454 0.454 0.44	A1553-18.1	rim	2.49	86	8	0.09	344.0	4.4	0.05481	0.00073	0.3552	7.14	0.05481	1.24	0.174	
A1553-12.1 rim 0.01 241 9 0.04 345.7 3.5 0.05510 0.0007 0.4116 2.18 0.05510 1.04 0.475 A1553-20.1 rim 0.66 305 10 0.03 346.2 2.0 0.05517 0.00074 0.3841 8.21 0.05539 1.19 0.416 A1553-8.1 core 0.14 133 86 0.46 351.7 6.6 0.05068 0.0018 0.4144 2.95 0.05608 1.78 0.603 A1553-20.2 core 0.00 231 141 0.63 345.7 4.5 0.06076 0.00073 0.5305 2.50 0.06608 1.099 0.434 A1553-20.2 core 0.03 202 99 0.51 422.0 4.4 0.06007 0.5337 3.03 0.06766 1.00 0.331 A1553-22.1 core 0.33 232 199 0.53 430.5 4.6 0.06097 0.5517 2.20 0.06999 1.01 0.462 A1553-1.2 core 0.14	A1553-7.2	rim	0.08	118	21	0.19	345.0	5.0	0.05498	0.00082	0.3906	3.11	0.05498	1.45	0.465	
A1553-20.1 rim 0.6 305 10 0.03 346.2 3.2 0.05517 0.00053 0.3995 2.05 0.05517 0.056 0.05453 A1553-3.1 rim 0.00 813 18 0.02 348.9 2.9 0.05562 0.00048 0.4107 1.33 0.05562 0.66 0.67 A1553-3.2 core 0.14 133 6.6 0.46 0.0067 0.4490 2.30 0.06331 0.67 0.4420 2.30 0.06331 0.97 0.424 A1553-2.0 core 0.03 202 99 0.51 422.0 4.5 0.06666 0.00077 0.5317 2.00 0.06990 1.00 0.445 A1553-17.1 core 0.00 209 116 0.57 435.5 5.7 0.06990 0.00094 0.5728 2.19 0.06990 1.22 0.554 A1553-14.1 core 0.01 296 166 0.58 447.9 5.0 0.07134 0.00082 0.5647 1.83 0.07194 1.040 0.555 3.53	A1553-12.1	rim	0.01	241	9	0.04	345.7	3.5	0.05510	0.00057	0.4116	2.18	0.05510	1.04	0.476	
A1553-13.1 rim 2.54 92 20 0.22 347.5 4.5 0.05539 0.00074 0.3841 8.2.1 0.05539 1.19 0.145 A1553-8.1 core 0.14 193 86 0.46 351.7 6.6 0.05562 0.00048 0.4144 2.95 0.05508 1.78 0.602 A1553-20.2 core 0.00 231 141 0.63 412.0 4.4 0.06600 0.00074 0.5305 2.50 0.06606 0.090 0.331 A1553-22.1 core 0.36 232 119 0.53 430.5 4.6 0.06600 0.00074 0.5317 2.20 0.06699 1.01 0.462 A1553-22.1 core 0.14 109 33 0.31 440.0 8.2 0.07063 0.00137 0.527 3.14 0.070698 1.84 0.314 1.04 0.564 A1553-12 core 0.13 1.66 0.28 459.2 5.0 0.07234 0.0724 1.34 0.07144 1.04 0.0564 1.57 0.156 <td>A1553-20.1</td> <td>rim</td> <td>0.06</td> <td>305</td> <td>10</td> <td>0.03</td> <td>346.2</td> <td>3.2</td> <td>0.05517</td> <td>0.00053</td> <td>0.3995</td> <td>2.05</td> <td>0.05517</td> <td>0.96</td> <td>0.468</td>	A1553-20.1	rim	0.06	305	10	0.03	346.2	3.2	0.05517	0.00053	0.3995	2.05	0.05517	0.96	0.468	
AL553-8.1 rim 0.00 813 18 0.02 348.9 2.9 0.05562 0.00048 0.4107 1.33 0.05562 0.66 0.647 AL553-61 core 0.14 193 86 0.46 351.7 6.6 0.05620 0.0108 0.4144 2.95 0.05608 1.060 0.6023 AL553-20.2 core 0.03 202 99 0.51 422.0 4.5 0.06600 0.00077 0.5137 3.03 0.06766 1.00 0.331 AL553-17.1 core 0.30 232 19 0.53 435.5 5.7 0.06996 0.00077 0.517 2.20 0.05986 1.22 0.554 AL553-17.1 core 0.01 266 1.66 0.58 447.9 5.0 0.07023 0.0094 0.5732 2.19 0.0598 1.22 0.554 AL553-13.1 core 0.01 246 950.3 4.5 0.07824 0.0094 0.5732 2.29 0.0724 1.61 0.07385 0.91 0.4564 1.53 0.3755 <td>A1553-13.1</td> <td>rim</td> <td>2.54</td> <td>92</td> <td>20</td> <td>0.22</td> <td>347.5</td> <td>4.5</td> <td>0.05539</td> <td>0.00074</td> <td>0.3841</td> <td>8.21</td> <td>0.05539</td> <td>1.19</td> <td>0.145</td>	A1553-13.1	rim	2.54	92	20	0.22	347.5	4.5	0.05539	0.00074	0.3841	8.21	0.05539	1.19	0.145	
AL553-6.1 core 0.14 193 86 0.46 351.7 6.6 0.05608 0.00168 0.414 2.95 0.05608 1.78 0.602 AL553-92.0 core 0.00 231 141 0.63 412.0 4.4 0.06600 0.00074 0.5307 3.03 0.06766 0.00 313 AL553-22.1 core 0.33 202 99 0.51 422.0 4.5 0.06766 0.00074 0.5337 3.03 0.66766 1.01 0.434 AL553-12.1 core 0.30 229 1.61 0.57 435.5 5.7 0.06989 0.00074 0.5527 3.14 0.07663 1.01 0.44 0.588 AL553-12.1 core 0.01 146 36 0.25 450.2 5.0 0.00714 0.00082 0.5447 1.83 0.07035 1.61 0.07035 0.11 0.444 0.331 AL553-1.1 core 0.00 39 15 0.39 472.6 7.0 0.0773 0.00014 0.5924 1.61 0.07385	A1553-8.1	rim	0.00	813	18	0.02	348.9	2.9	0.05562	0.00048	0.4107	1.33	0.05562	0.86	0.647	
A1553-92. core 0.39 237 103 0.45 395.7 4.1 0.0667 0.449 2.30 0.06531 0.97 0.424 A1553-20.2 core 0.03 202 99 0.51 422.0 4.4 0.06600 0.00073 0.5305 2.50 0.06600 0.99 0.375 A1553-12.1 core 0.03 202 99 0.51 422.0 4.5 0.06766 0.00074 0.5317 2.20 0.06909 1.22 0.554 A1553-12.2 core 0.00 296 166 0.58 447.9 5.0 0.07194 0.00082 0.5647 1.83 0.07194 1.04 0.568 A1553-12.2 core 0.00 39 1.5 0.39 472.6 7.0 0.07385 0.00074 0.5924 1.61 0.07385 0.91 0.568 A1553-12.2 core 0.00 39 1.5 0.39 472.6 7.0 0.07905 0.00118 0.6492 4.34 0.07607 1.44 0.07802 0.9770 1.44 0.032	A1553-6.1	core	0.14	193	86	0.46	351.7	6.6	0.05608	0.00108	0.4144	2.95	0.05608	1.78	0.602	
A1553-20.2. core 0.00 231 141 0.63 412.0 4.4 0.06600 0.0073 0.5305 2.50 0.06600 0.99 0.331 A1553-12.2. core 0.36 222 119 0.53 430.5 4.5 0.06766 0.00077 0.5517 2.20 0.06996 1.01 0.431 A1553-2.2. core 0.14 109 33 0.31 440.0 8.2 0.07063 0.00094 0.5728 2.19 0.06996 1.04 0.584 A1553-1.1 core 0.00 296 459.3 4.5 0.00724 0.00084 0.5728 2.29 0.07234 1.11 0.486 A1553-3.1.2 core 0.00 39 15 0.39 472.6 7.0 0.07072 0.0014 0.6007 1.44 0.332 A1553-3.1.2 core 0.00 31 484.3 4.8 0.07067 0.0018 0.6492 1.80 0.0782 0.97 0.510 A1553-51.2 core 0.00 142 646 486.7 5.3 <td>A1553-9.2</td> <td>core</td> <td>0.39</td> <td>237</td> <td>103</td> <td>0.45</td> <td>395.7</td> <td>4.1</td> <td>0.06331</td> <td>0.00067</td> <td>0.4490</td> <td>2.30</td> <td>0.06331</td> <td>0.97</td> <td>0.424</td>	A1553-9.2	core	0.39	237	103	0.45	395.7	4.1	0.06331	0.00067	0.4490	2.30	0.06331	0.97	0.424	
A1553-18.2 core 0.03 202 99 0.51 422.0 4.5 0.06766 0.00074 0.5337 3.03 0.06766 1.00 0.331 A1553-21.1 core 0.00 209 116 0.57 435.5 7.7 0.06989 0.00094 0.5728 2.19 0.06989 1.22 0.558 A1553-12.1 core 0.00 296 166 0.58 447.9 5.0 0.07194 0.00082 0.5647 1.83 0.07194 1.04 0.588 A1553-12.1 core factured 0.01 146 36 0.25 450.2 5.0 0.07235 0.00014 0.5924 1.61 0.07385 0.91 0.568 A1553-12.1 core 0.00 30 112 0.49 480.3 5.4 0.07735 0.00014 0.6990 1.80 0.07735 1.09 0.633 A1553-12.2 core 0.00 246 91 0.38 484.3 4.8 0.07602 0.2018 0.07785 1.09 0.633 A1553-51.2 core <	A1553-20.2	core	0.00	231	141	0.63	412.0	4.4	0.06600	0.00073	0.5305	2.50	0.06600	0.99	0.395	
A1553-22.1 core 0.36 232 119 0.53 430.5 4.6 0.006906 0.00077 0.5517 2.20 0.06906 1.01 0.462 A1553-12.1 core 0.14 109 33 0.31 440.0 8.2 0.0763 0.00137 0.5527 3.14 0.07063 1.84 0.584 A1553-11.1 core 0.01 146 36 0.25 450.2 5.0 0.07144 0.00082 0.5647 1.83 0.07134 1.11 0.466 A1553-31.2 core 0.01 146 36 0.25 450.2 5.0 0.07234 0.00082 0.5647 1.83 0.07135 0.10 0.456 A1553-12.1 core 0.00 39 15 0.39 472.6 7.0 0.07607 0.00118 0.6432 4.34 0.07607 1.44 0.332 A1553-5.1 core 0.00 142 66 0.48 486.7 5.3 0.0092 0.6447 2.18 0.08035 1.00 0.453 1.03 0.463	A1553-18.2	core	0.03	202	99	0.51	422.0	4.5	0.06766	0.00074	0.5337	3.03	0.06766	1.00	0.331	
A1553-17.1 core 0.00 209 116 0.57 435.5 5.7 0.06989 0.00094 0.5728 2.19 0.06989 1.22 0.554 A1553-10.1 core 0.00 296 166 0.58 447.9 5.0 0.07194 0.00084 0.5527 3.14 0.07063 0.07194 1.04 0.668 A1553-1.2 core 0.00 351 200 0.59 459.3 4.5 0.07385 0.00044 0.5924 1.61 0.07385 0.91 0.669 A1553-1.2 core 0.00 39 15 0.39 472.6 7.0 0.07035 0.0014 0.5924 1.61 0.07385 0.91 0.669 A1553-19.2 core 0.00 30 142 0.49 480.3 4.8 0.07602 0.00044 0.6320 2.28 0.07842 1.03 0.453 A1553-19.2 core 0.00 142 66 486.7 5.3 0.07842 0.0088 0.6320 2.28 0.07842 1.03 0.464 A1553-19.1	A1553-22.1	core	0.36	232	119	0.53	430.5	4.6	0.06906	0.00077	0.5517	2.20	0.06906	1.01	0.462	
A1553-8.2 core 0.14 109 33 0.31 440.0 8.2 0.07063 0.0127 0.527 3.14 0.07063 1.84 0.584 A1553-1.1 core 0.00 296 166 0.58 447.9 5.0 0.07194 0.00082 0.5647 1.83 0.07134 1.04 0.584 A1553-1.1 core 0.01 146 36 0.25 450.0 5.0 0.07234 0.00084 0.5732 2.29 0.07234 1.11 0.486 A1553-1.1 core 0.00 39 15 0.39 472.6 7.0 0.07735 0.00091 0.6090 1.80 0.07755 1.09 0.631 A1553-13.2 core 0.00 246 91 0.38 484.3 4.8 0.07785 0.00081 0.6195 1.90 0.07852 1.09 0.510 A1553-1.1 core 0.00 142 66 0.44 486.7 5.3 0.07842 0.0091 0.6447 2.18 0.0797 1.01 0.454 4.554 1.03 <t< td=""><td>A1553-17.1</td><td>core</td><td>0.00</td><td>209</td><td>116</td><td>0.57</td><td>435.5</td><td>5.7</td><td>0.06989</td><td>0.00094</td><td>0.5728</td><td>2.19</td><td>0.06989</td><td>1.22</td><td>0.558</td></t<>	A1553-17.1	core	0.00	209	116	0.57	435.5	5.7	0.06989	0.00094	0.5728	2.19	0.06989	1.22	0.558	
Al553-14.1 core 0.00 296 166 0.58 447.9 5.0 0.07134 0.00082 0.547 1.83 0.07194 1.04 0.586 Al553-1.2 core fractured 0.01 146 36 0.25 450.2 5.0 0.07234 0.00084 0.5732 2.29 0.07235 0.017 1.44 0.352 Al553-1.1 core 0.00 39 15 0.39 472.6 7.0 0.07607 0.00118 0.6432 4.34 0.07735 1.09 0.603 Al553-1.2 core 0.00 301 142 0.49 480.3 5.4 0.077607 0.0018 0.6490 1.80 0.07735 1.09 0.603 Al553-1.2 core 0.00 142 66 0.48 486.7 5.3 0.07842 0.00088 0.6320 2.28 0.07842 1.03 0.447 2.18 0.07835 1.06 0.432 Al553-51.1 core 0.01 1258 69 0.66 323.7 2.7 0.05150 0.0047 0.394 1.61	A1553-8.2	core	0.14	109	33	0.31	440.0	8.2	0.07063	0.00137	0.5527	3.14	0.07063	1.84	0.584	
A1553-1.2 core fractured 0.01 146 36 0.25 450.2 5.0 0.07234 0.00084 0.5732 2.29 0.07234 1.11 0.486 A1553-1.1 core 0.00 39 15 0.39 472.6 7.0 0.07607 0.00118 0.6432 4.34 0.07607 1.44 0.332 A1553-10.2 core 0.00 301 142 0.49 480.3 5.4 0.07802 0.0001 1.80 0.07735 1.09 0.6133 A1553-1.2 core 0.00 142 66 0.48 486.7 5.3 0.07842 0.00088 0.6320 2.28 0.07842 1.03 0.453 A1553-51.1 core 0.00 179 80 0.46 498.2 5.5 0.00088 0.6321 2.28 0.07842 1.03 0.468 A1553-51.1 core 0.00 179 80 0.46 498.2 5.5 0.00048 0.3725 2.00 0.05097 0.94 4.66 0.469 1.51 0.500 0.66 0.3745 <td>A1553-14.1</td> <td>core</td> <td>0.00</td> <td>296</td> <td>166</td> <td>0.58</td> <td>447.9</td> <td>5.0</td> <td>0.07194</td> <td>0.00082</td> <td>0.5647</td> <td>1.83</td> <td>0.07194</td> <td>1.04</td> <td>0.568</td>	A1553-14.1	core	0.00	296	166	0.58	447.9	5.0	0.07194	0.00082	0.5647	1.83	0.07194	1.04	0.568	
A1533-3.1 core 0.07 351 200 0.59 459.3 4.5 0.07385 0.0074 0.5924 1.61 0.07385 0.91 0.538 A1533-2.1 core 0.00 301 142 0.49 480.3 5.4 0.07735 0.00018 0.6090 1.80 0.07735 1.09 0.07802 0.97 0.510 A1553-19.2 core 0.00 142 66 0.48 486.7 5.3 0.07842 0.00080 0.6195 1.90 0.07802 0.97 0.510 A1553-12.1 core 0.00 142 66 0.48 486.7 5.3 0.07842 0.00088 0.6320 2.28 0.07842 1.03 0.453 A1553-11 core 0.00 179 80 0.46 498.2 5.5 0.8055 0.00092 0.6447 2.18 0.08055 1.06 0.464 A1554-11 core 0.01 1258 69 0.06 323.7 2.7 0.05150 0.00045 0.3745 1.27 0.05150 0.05241 0.89	A1553-1.2	core fractured	0.01	146	36	0.25	450.2	5.0	0.07234	0.00084	0.5732	2.29	0.07234	1.11	0.486	
Al55-2.1 core 0.00 39 15 0.39 472.6 7.0 0.07607 0.00118 0.6432 4.34 0.07607 1.49 0.633 Al553-13.2 core 0.00 246 91 0.38 484.3 4.8 0.077802 0.0901 0.6090 1.80 0.07735 1.09 0.603 Al553-13.2 core 0.00 142 66 0.48 486.7 5.3 0.07842 0.00080 0.6195 1.90 0.07842 1.03 0.433 Al553-1.1 core 0.00 142 66 0.48 486.7 5.3 0.07842 0.00080 0.6320 2.28 0.07842 1.03 0.438 Al554-51 core 0.00 128 69 0.06 323.7 2.7 0.05150 0.00045 0.3745 1.27 0.05150 0.86 0.675 Al554-51 0.01 128 69 0.06 323.7 3.2 0.05241 0.00047 0.3904 1.61 0.05241 0.89 0.525 Al554-11 1011	A1553-3.1	core	0.07	351	200	0.59	459.3	4.5	0.07385	0.00074	0.5924	1.61	0.07385	0.91	0.568	
A1553-13.2 core 0.00 301 142 0.49 480.3 5.4 0.07/35 0.00091 0.6090 1.80 0.07/35 1.09 0.603 A1553-12.2 core 0.00 142 66 0.48 486.7 5.3 0.07842 0.00088 0.6320 2.28 0.07842 1.03 0.453 A1553-12.1 core 0.00 179 80 0.46 486.2 5.5 0.08035 0.00092 0.6447 2.18 0.08035 1.06 0.488 Mafic granulite (A1554) 0.0048 0.3725 2.00 0.05097 0.94 0.469 A1554-51 0.01 1.258 69 0.06 323.7 2.7 0.05150 0.00045 0.3745 1.27 0.05150 0.86 0.675 A1554-12.1 0.07 666 43 0.07 329.3 2.9 0.05241 0.00045 0.3745 1.27 0.05150 0.8572 0.05281 1.03 0.4	A1553-2.1	core	0.00	39	15	0.39	4/2.6	7.0	0.07607	0.00118	0.6432	4.34	0.07607	1.44	0.332	
A1553-19.2 core 0.00 246 91 0.38 484.3 4.8 0.07802 0.00800 0.6195 1.90 0.07802 0.97842 1.03 0.453 A1553-51.1 core 0.00 179 80 0.46 498.2 5.5 0.08035 0.0092 0.6447 2.18 0.08035 1.06 0.488 Mafic granulite (A1554) A 0.01 1258 69 0.66 323.7 2.7 0.05150 0.0048 0.3725 2.00 0.05097 0.94 0.469 A1554-51 0.01 1258 69 0.66 323.7 2.7 0.05150 0.0048 0.3725 2.00 0.055150 0.86 0.675 A1554-51 0.01 1258 69 0.66 323.7 2.7 0.05150 0.0047 0.3904 1.61 0.05241 0.89 0.552 A1554-61.1 rim light 0.10 354 31 0.09 32.8 3.4 0.05296 0.3981 1.95 0.05296 0.99 0.429 A1554-51.1 0.10	A1553-13.2	core	0.00	301	142	0.49	480.3	5.4	0.07735	0.00091	0.6090	1.80	0.07735	1.09	0.603	
A1553-5.1 core 0.00 142 66 0.48 486.7 5.3 0.00482 0.00088 0.6320 2.28 0.07842 1.03 0.453 A1553-21.1 core 0.00 179 80 0.46 498.2 5.5 0.08035 0.0092 0.6447 2.18 0.08035 1.06 0.488 Matic granulite (A1554) 0.0835 1.03 0.463 A1554-11.1 sector 0.08 339 24 0.07 320.4 3.0 0.05097 0.0048 0.3725 2.00 0.05097 0.94 0.469 A1554-51.1 0.01 1258 69 0.66 323.7 2.7 0.05150 0.00045 0.3745 1.27 0.05241 0.86 0.652 A1554-51.1 0.01 354 16 0.10 331.8 3.4 0.05281 0.00055 0.3857 2.52 0.05281 1.03 0.464 93.54	A1553-19.2	core	0.00	246	91	0.38	484.3	4.8	0.07802	0.00080	0.6195	1.90	0.07802	0.97	0.510	
A1553-21.1 core 0.00 1/9 80 0.46 498.2 5.5 0.08035 0.00092 0.6447 2.18 0.08035 1.06 0.488 Mafic granulite (A1554) A1554-11.1 sector 0.08 339 24 0.07 320.4 3.0 0.05097 0.00048 0.3725 2.00 0.05097 0.94 0.469 A1554-12.1 0.07 606 43 0.07 329.3 2.9 0.05241 0.00047 0.3904 1.61 0.05281 1.03 0.469 A1554-5.1 0.07 606 43 0.07 329.3 2.9 0.05241 0.00047 0.3904 1.61 0.05281 1.03 0.489 A1554-6.1 rim light 0.10 354 31 0.09 332.8 3.4 0.05296 0.00052 0.3880 2.30 0.05296 0.99 0.429 A1554-51.1 0.10 354 31 0.09 332.8 3.4 0.05296 0.00052 0.3880 2.30 0.05296 0.99 0.429 A1554-7.1 0.	A1553-5.1	core	0.00	142	66	0.48	486.7	5.3	0.07842	0.00088	0.6320	2.28	0.07842	1.03	0.453	
Mafic granulite (A1554) A1554-11.1 sector 0.08 339 24 0.07 320.4 3.0 0.05097 0.0048 0.3725 1.27 0.05150 0.86 0.675 A1554-12.1 0.07 606 43 0.07 329.3 2.9 0.05241 0.00047 0.3904 1.61 0.05241 0.89 0.552 A1554-51 0.01 166 0.10 331.8 3.4 0.05286 0.0055 0.3857 2.52 0.05281 1.03 0.408 A1554-6.1 rim light 0.10 354 31 0.09 332.8 3.4 0.05298 0.00056 0.3981 1.95 0.05298 1.04 0.535 A1554-7.1 0.12 360 27 0.08 333.0 3.0 0.05339 0.00056 0.3981 1.95 0.05391 0.92 0.400 A1554-10.1 rim light 0.14 80 11 0.14 335.3 4.2 0.05339 0.00054 0.3907 1.59 0.05354 1.00 0.627 A1554-10.1 <td>A1553-21.1</td> <td>core</td> <td>0.00</td> <td>179</td> <td>80</td> <td>0.46</td> <td>498.2</td> <td>5.5</td> <td>0.08035</td> <td>0.00092</td> <td>0.6447</td> <td>2.18</td> <td>0.08035</td> <td>1.06</td> <td>0.488</td>	A1553-21.1	core	0.00	179	80	0.46	498.2	5.5	0.08035	0.00092	0.6447	2.18	0.08035	1.06	0.488	
A1554-11.1 sector 0.08 339 24 0.07 320.4 3.0 0.05097 0.0048 0.3725 2.00 0.05097 0.944 0.469 A1554-5.1 0.01 1258 69 0.06 323.7 2.7 0.05150 0.00045 0.3745 1.27 0.05150 0.866 0.675 A1554-5.1 0.07 606 43 0.07 329.3 2.9 0.05241 0.00047 0.3904 1.61 0.05281 1.03 0.408 A1554-6.1 rim light 0.16 211 5 0.02 332.7 3.2 0.05296 0.00055 0.3857 2.52 0.05281 1.03 0.408 A1554-6.1 rim light 0.10 354 31 0.09 332.8 3.4 0.05298 0.00056 0.3851 1.95 0.05298 1.04 0.535 A1554-10.1 rim light 0.14 80 11 0.14 333.0 3.0 0.05331 0.00049 0.3988 2.29 0.05354 1.00 0.627 A1554-10.1 rim light <td>Mafic granu</td> <td>lite (A1554)</td> <td></td>	Mafic granu	lite (A1554)														
Al534-5.1 0.01 1258 69 0.06 323.7 2.7 0.05150 0.0045 0.3745 1.27 0.05150 0.86 0.675 Al554-12.1 0.07 606 43 0.07 329.3 2.9 0.05241 0.00047 0.3904 1.61 0.052241 0.89 0.552 Al554-6.1 rim light 0.10 354 31 0.09 332.8 3.4 0.05296 0.00055 0.3857 2.52 0.05281 1.03 0.408 Al554-6.1 rim light 0.10 354 31 0.09 332.8 3.4 0.05296 0.00055 0.3867 2.52 0.05281 1.04 0.535 Al554-7.1 0.12 360 27 0.08 333.0 3.0 0.05331 0.00049 0.3988 2.29 0.05331 0.92 0.400 Al554-1.1 rim light 0.14 80 11 0.14 335.3 4.2 0.05339 0.00068 0.3794 3.75 0.05339 1.24 0.331 Al554-12.2 0.00 482	A1554-11.1	sector	0.08	339	24	0.07	320.4	3.0	0.05097	0.00048	0.3725	2.00	0.05097	0.94	0.469	
Al554-12.1 0.07 606 43 0.07 329.3 2.9 0.05241 0.00047 0.3904 1.61 0.05241 0.89 0.552 Al554-4.1 rim light 0.11 163 16 0.10 331.8 3.4 0.05281 0.00055 0.3857 2.52 0.05286 0.99 0.429 Al554-6.1 rim light 0.10 354 31 0.09 332.8 3.4 0.05296 0.00055 0.3857 2.52 0.05296 0.99 0.429 Al554-7.1 0.10 354 31 0.09 332.8 3.4 0.05298 0.00056 0.3981 1.95 0.05298 1.04 0.535 Al554-10.1 rim light 0.14 80 11 0.14 335.3 4.2 0.05339 0.00068 0.3794 3.75 0.05339 1.24 0.311 Al554-10.1 rim light 0.14 89 47 0.08 336.2 3.3 0.05357 0.00054 0.3907 1.59 0.05357 0.95 0.539 Al554-12.2 0.00	A1554-5.1		0.01	1258	69	0.06	323.7	2.7	0.05150	0.00045	0.3745	1.27	0.05150	0.86	0.675	
A1554-4.1 rim light 0.11 163 16 0.10 331.8 3.4 0.05281 0.00055 0.3857 2.52 0.05281 1.03 0.408 A1554-6.1 rim light 0.06 211 5 0.02 332.7 3.2 0.05296 0.00052 0.3880 2.30 0.05296 0.99 0.429 A1554-9.1 0.10 354 31 0.09 332.8 3.4 0.05298 0.00056 0.3981 1.95 0.05298 1.04 0.535 A1554-10.1 rim light 0.14 80 11 0.14 335.3 4.2 0.05339 0.00068 0.3794 3.75 0.0539 1.24 0.331 A1554-10.1 rim light 0.14 80 11 0.14 336.2 3.3 0.05547 0.00054 0.3907 1.59 0.05354 1.00 0.627 A1554-12.2 0.00 482 62 0.13 336.4 3.2 0.05367 0.00054 0.3907 1.76 0.05357 0.95 0.539 A1554-12.2 0.00	A1554-12.1		0.07	606	43	0.07	329.3	2.9	0.05241	0.00047	0.3904	1.61	0.05241	0.89	0.552	
A1534-5.1 min light 0.06 211 5 0.02 332.7 3.2 0.05296 0.00052 0.3880 2.30 0.05296 0.99 0.429 A1554-9.1 0.10 354 31 0.09 332.8 3.4 0.05298 0.00056 0.3981 1.95 0.05298 1.04 0.533 A1554-7.1 0.12 360 27 0.08 333.0 3.0 0.05301 0.00049 0.3988 2.29 0.05301 0.92 0.400 A1554-10.1 rim light 0.14 80 11 0.14 335.3 4.2 0.05339 0.00068 0.3794 3.75 0.05394 1.04 0.331 A1554-12.2 0.00 482 62 0.13 36.4 3.2 0.05357 0.00052 0.3907 1.76 0.05354 1.00 0.627 A1554-12.2 0.00 482 62 0.13 36.4 3.2 0.05367 0.00047 0.3907 1.76 0.05374 0.95 0.539 A1554-13.1 0.01 854 57 0.07<	A1554-4.1	rim light	0.11	163	16	0.10	331.8	3.4	0.05281	0.00055	0.3857	2.52	0.05281	1.03	0.408	
A1534-9.1 0.10 354 31 0.09 332.8 3.4 0.05298 0.00056 0.3981 1.95 0.05298 1.04 0.535 A1554-7.1 0.12 360 27 0.08 333.0 3.0 0.005301 0.00049 0.3988 2.29 0.05301 0.92 0.400 A1554-10.1 rim light 0.14 80 11 0.14 335.3 4.2 0.05339 0.00068 0.3794 3.75 0.05339 1.24 0.331 A1554-10.1 rim light 0.04 589 47 0.08 336.2 3.3 0.05357 0.00054 0.3907 1.59 0.05357 0.95 0.539 A1554-12.2 0.00 482 62 0.13 336.4 3.2 0.05367 0.00052 0.3907 1.76 0.05357 0.95 0.539 A1554-13.1 0.01 854 57 0.07 337.5 3.2 0.05374 0.00047 0.3977 1.33 0.05413 0.0664 0.433 A1554-13.1 0.02 826 49 <t< td=""><td>A1554-6.1</td><td>rim light</td><td>0.06</td><td>211</td><td>5</td><td>0.02</td><td>332.7</td><td>3.2</td><td>0.05296</td><td>0.00052</td><td>0.3880</td><td>2.30</td><td>0.05296</td><td>0.99</td><td>0.429</td></t<>	A1554-6.1	rim light	0.06	211	5	0.02	332.7	3.2	0.05296	0.00052	0.3880	2.30	0.05296	0.99	0.429	
A1554-7.1 0.12 360 27 0.08 333.0 3.0 0.05301 0.0049 0.3988 2.29 0.05301 0.92 0.400 A1554-10.1 rim light 0.14 80 11 0.14 335.3 4.2 0.05339 0.00068 0.3794 3.75 0.05339 1.24 0.311 A1554-10.1 rim light 0.04 589 47 0.08 336.2 3.3 0.05354 0.00054 0.3907 1.59 0.05354 1.00 0.627 A1554-12.2 0.00 482 62 0.13 336.4 3.2 0.05367 0.00052 0.3907 1.76 0.05357 0.95 0.539 A1554-13.1 0.01 854 57 0.07 337.0 2.9 0.05367 0.00047 0.3848 1.33 0.05367 0.87 0.651 A1554-13.1 0.04 254 16 0.07 337.5 3.2 0.05374 0.00047 0.3977 1.35 0.05413 0.86 0.639 A1554-13.2 0.05 764 49 0	A1554-9.1		0.10	354	31	0.09	332.8	3.4	0.05298	0.00056	0.3981	1.95	0.05298	1.04	0.535	
A1534-10.1 Infinition 0.14 80 11 0.14 335.3 4.2 0.05339 0.00068 0.394 3.75 0.05339 1.24 0.331 A1534-1.1 0.04 589 47 0.08 336.2 3.3 0.05357 0.00054 0.3907 1.59 0.05357 1.00 0.627 A1554-1.2 0.00 482 62 0.13 336.4 3.2 0.05357 0.00052 0.3907 1.76 0.05357 0.95 0.539 A1554-12.2 0.01 854 57 0.07 337.0 2.9 0.05367 0.00047 0.3848 1.33 0.05367 0.87 0.651 A1554-13.1 0.04 254 16 0.07 337.5 3.2 0.05374 0.00047 0.3848 1.33 0.05367 0.86 0.636 A1554-8.1 0.02 826 49 0.06 339.8 2.9 0.05413 0.00047 0.3977 1.35 0.05413 0.86 0.636 A1554-13.2 0.05 764 49 0.07 340.6 </td <td>A1554-7.1</td> <td>where the last</td> <td>0.12</td> <td>360</td> <td>27</td> <td>0.08</td> <td>333.0</td> <td>3.0</td> <td>0.05301</td> <td>0.00049</td> <td>0.3988</td> <td>2.29</td> <td>0.05301</td> <td>0.92</td> <td>0.400</td>	A1554-7.1	where the last	0.12	360	27	0.08	333.0	3.0	0.05301	0.00049	0.3988	2.29	0.05301	0.92	0.400	
Al534-1.1 0.04 369 47 0.06 336.2 5.3 0.0034 0.0004 0.597 1.59 0.0334 1.00 0.627 Al534-1.2 0.00 482 62 0.13 336.4 3.2 0.05357 0.00052 0.3907 1.76 0.05357 0.95 0.539 Al554-12.2 0.01 854 57 0.07 337.0 2.9 0.05367 0.00052 0.3907 1.76 0.05357 0.95 0.651 Al554-13.1 0.04 254 16 0.07 337.5 3.2 0.05374 0.00053 0.4121 2.20 0.05374 0.98 0.443 Al554-8.1 0.02 826 49 0.06 339.8 2.9 0.05413 0.00047 0.3977 1.35 0.05413 0.86 0.636 Al554-13.2 0.05 764 49 0.07 340.6 3.3 0.05426 0.00054 0.3997 1.56 0.05426 0.98 0.639 Al554-13.2 0.00 747 56 0.08 344.6 3.3	A1554-10.1	rim light	0.14	80	11	0.14	335.3	4.2	0.05339	0.00068	0.3794	3.75	0.05339	1.24	0.331	
A1534-12.2 0.00 462 62 0.13 336.4 5.2 0.00052 0.597 1.76 0.0537 0.95 0.539 A1554-2.1 0.01 854 57 0.07 337.0 2.9 0.05367 0.0047 0.3848 1.33 0.05367 0.87 0.651 A1554-13.1 0.04 254 16 0.07 337.5 3.2 0.05374 0.00053 0.4121 2.20 0.05374 0.98 0.443 A1554-8.1 0.02 826 49 0.06 339.8 2.9 0.05413 0.00047 0.3977 1.35 0.05413 0.86 0.636 A1554-13.2 0.05 764 49 0.07 340.6 3.3 0.05426 0.00054 0.3923 1.54 0.05426 0.98 0.639 A1554-14.1 0.00 747 56 0.08 346.2 4.1 0.05517 0.00054 0.3997 1.56 0.05490 0.97 0.618 A1554-3.2 0.00 445 36 0.08 346.2 4.1 0.05517	A1554-1.1		0.04	209	47	0.08	330.2	3.3	0.05354	0.00054	0.3907	1.59	0.05354	1.00	0.627	
A1554-13.1 0.01 0.04 254 16 0.07 337.5 3.2 0.05374 0.00047 0.3646 1.33 0.05367 0.86 0.413 A1554-13.1 0.04 254 16 0.07 337.5 3.2 0.05374 0.00053 0.4121 2.20 0.05374 0.98 0.443 A1554-8.1 0.02 826 49 0.06 339.8 2.9 0.05413 0.00047 0.3977 1.35 0.05413 0.86 0.639 A1554-13.2 0.05 764 49 0.07 340.6 3.3 0.05426 0.00054 0.3923 1.54 0.05426 0.98 0.639 A1554-14.1 0.00 747 56 0.08 344.6 3.3 0.05490 0.3997 1.56 0.05490 0.97 0.618 A1554-3.2 0.00 445 36 0.08 346.2 4.1 0.05517 0.00067 0.4076 1.87 0.05517 1.20 0.643 A1554-3.2 0.00 445 36 0.08 346.2 4.1	A1554-12.2		0.00	402	62	0.13	2220	3.2	0.05357	0.00052	0.3907	1.70	0.05357	0.95	0.539	
A1554-13.1 0.04 2.94 16 0.07 537.5 5.2 0.05374 0.00053 0.4121 2.20 0.05374 0.98 0.443 A1554-8.1 0.02 826 49 0.06 339.8 2.9 0.05413 0.00047 0.3977 1.35 0.05413 0.86 0.639 A1554-8.1 0.05 764 49 0.07 340.6 3.3 0.05426 0.00054 0.3977 1.35 0.05426 0.98 0.639 A1554-13.2 0.05 764 49 0.07 340.6 3.3 0.05426 0.00054 0.3923 1.54 0.05426 0.98 0.639 A1554-13.2 0.00 747 56 0.08 344.6 3.3 0.05490 0.00054 0.3997 1.56 0.05490 0.97 0.618 A1554-3.2 0.00 445 36 0.08 346.2 4.1 0.05517 0.00067 0.4076 1.87 0.05517 1.20 0.633	A1554-2.1		0.01	004	5/	0.07	337.U	2.9	0.0530/	0.00047	0.3048	1.33	0.0530/	0.07	0.051	
A153+3.1 0.02 620 49 0.00 539.6 2.9 0.05413 0.0047 0.3977 1.35 0.05413 0.86 0.636 A155+13.2 0.05 764 49 0.07 340.6 3.3 0.05426 0.00054 0.3923 1.54 0.05426 0.98 0.639 A155+14.1 0.00 747 56 0.08 344.6 3.3 0.05490 0.00054 0.3923 1.56 0.05426 0.98 0.639 A155+3.2 0.00 445 36 0.08 346.2 4.1 0.05517 0.00067 0.4076 1.87 0.05517 1.20 0.643 A155+3.3 inherited core 0.26 82 28 0.35 377.7 6.2 0.06034 0.00103 0.4384 4.12 0.06034 1.60 0.387	A1554-13.1		0.04	254	10	0.07	33/.5	3.2	0.05374	0.00053	0.4121	2.20	0.05374	0.98	0.443	
A155+13.2 0.05 704 49 0.07 540.6 5.5 0.05420 0.00054 0.592.5 1.54 0.05420 0.98 0.639 A1554-14.1 0.00 747 56 0.08 344.6 3.3 0.05490 0.00054 0.3997 1.56 0.05490 0.97 0.618 A1554-3.2 0.00 445 36 0.08 346.2 4.1 0.05517 0.00067 0.4076 1.87 0.05517 1.20 0.643 A1554-13.3 inherited core 0.26 82 28 0.35 377.7 6.2 0.06034 0.00103 0.4384 4.12 0.06034 1.60 0.387	A155/ 12 2		0.02	020 761	49	0.00	229.8	2.9	0.05413	0.00047	0.39//	1.35	0.05413	0.80	0.030	
A1554-13.1 0.00 7-7 30 0.00 344.0 5.3 0.005490 0.005490 0.0990 0.97 0.016 A1554-3.2 0.00 445 36 0.08 346.2 4.1 0.05517 0.00067 0.4076 1.87 0.05517 1.20 0.643 A1554-3.3 inherited core 0.26 82 28 0.35 377.7 6.2 0.06034 0.00103 0.4384 4.12 0.06034 1.60 0.387	A1554-13.2		0.05	704	49	0.07	340.0	3.3 วิว	0.05420	0.00054	0.3923	1.54	0.05420	0.98	0.039	
A1554-13 3 inherited one 0.26 82 28 0.35 377 7 6 2 0.06034 0.00103 0.4384 4.12 0.06024 1.60 0.387	A1554-14.1		0.00	/4/	36	0.00	344.0	3.3 / 1	0.03490	0.00054	0.3997	1.00	0.03490	1 20	0.010	
	A1554-13 3	inherited core	0.00	87	28	0.00	377 7	4.1	0.05517	0.00007	0.4384	4 1 7	0.05517	1.20	0.043	

 $Pb_c \% = percent of common Pb$

Table 3. LA-ICPMS analyses of zircons.

	A1554-	A1553-																					
	2core	7core	8core	1core	12core	12a	14core	6rim	3rim	10rim	1core	4core	3core	6core	21core	20core	19core	1rim	11rim	21rim	13rim	15rim	16rim
Р	89	85	107	106	94	178	130	65	66	70	84	190	361	286	264	255	208	50	90	49	43	119	42
Ca	bdl	0.01	bdl	0.00	bdl	bdl	bdl	bdl															
Ti	7.4	6.1	7.8	9.0	6.2	6.5	7.7	5.6	11	10.0	5.4	8.6	16.9	8.2	8.1	9.7	30	7.1	14	10.0	6.4	14	6.3
Sr	0.20	0.16	0.23	0.17	0.14	0.20	0.21	0.08	0.13	0.22	0.16	0.50	1.25	0.48	0.42	0.59	0.59	0.08	0.06	0.16	0.08	0.07	0.09
Y	380	286	564	311	180	452	444	86	49	68	185	1543	3403	1291	1673	1857	835	48	32	29	45	68	49
Nb	0.76	0.60	0.72	0.86	0.77	0.81	0.96	0.22	0.16	0.17	0.50	0.87	1.6	1.7	2.8	1.0	1.9	0.49	0.25	0.12	0.26	0.24	0.24
La	0.003	bdl	0.004	0.004	0.031	0.004	0.005	0.026	bdl	0.20	0.024	0.018	0.21	0.037	0.007	0.053	0.23	0.002	0.032	bdl	bdl	0.014	bdl
Ce	3.8	2.9	4.6	4.3	3.4	6.5	4.9	3.5	2.8	5.6	6.5	11.8	14.4	9.8	7.2	9.4	5.7	1.5	8.0	4.8	1.4	8.2	3.2
Pr	0.01	0.01	0.05	0.01	0.02	0.03	0.02	0.06	0.03	0.12	0.02	0.09	0.27	0.05	0.10	0.17	0.08	0.004	0.05	0.04	bdl	0.07	bdl
Nd	0.25	0.20	0.98	0.24	0.22	0.52	0.47	0.74	0.49	1.15	0.28	1.93	4.6	1.03	2.00	3.02	0.96	0.09	0.69	0.48	0.08	1.01	0.31
Sm	0.66	0.60	2.31	0.64	0.38	1.3	1.1	1.1	0.92	1.04	0.60	4.0	12	2.6	4.7	6.7	2.1	0.15	0.89	0.84	0.22	1.65	0.45
Eu	0.42	0.34	1.1	0.37	0.20	0.68	0.58	0.62	0.44	0.46	0.25	1.1	2.7	0.66	0.76	1.7	0.32	0.11	0.36	0.36	0.14	0.46	0.24
Gd	4.3	3.5	10.6	4.0	2.1	7.0	6.2	4.3	3.1	2.3	3.3	22	74	19	30	38.0	13.3	0.8	2.5	2.1	1.2	4.7	1.7
Tb	1.87	1.49	3.82	1.71	0.91	2.73	2.49	1.21	0.85	0.58	1.21	8.74	28	7.91	12	14	5.4	0.34	0.57	0.58	0.43	1.09	0.54
Dy	26	21	47	23	13	35	33	11	6.6	5.8	15	118	334	109	154	171	73	3.95	4.55	3.84	4.50	8.99	5.39
Ho	12	8.8	18	9.6	5.4	14	14	3.0	1.7	2.2	5.7	50	122	43	61	63	29	1.4	1.1	1.0	1.4	2.3	1.6
Er	63	46	87	50	29	74	72	11	5.4	10	28	250	524	211	269	287	136	5.7	3.3	2.8	5.3	7.1	5.8
Tm	17	12	21	13	7.7	18	18	1.9	0.9	2.5	7.1	60	109	48	60	63	31	1.2	0.6	0.47	1.1	1.3	1.0
Yb	212	148	247	155	93	215	223	16	7.7	29	84	638	1043	499	590	635	317	13	4.4	4.1	10	10	10
Lu	44	30	48	31	19	41	44	2.4	1.2	5.8	16	110	161	85	94	103	54	2.1	0.59	0.84	1.8	1.4	1.5
Hf	11827	11509	10880	10662	11313	10143	10640	9745	10810	8545	10472	9526	7779	8321	7913	8127	8766	10566	8394	8610	9760	7550	8853
Та	0.53	0.44	0.59	0.53	0.70	0.35	0.54	0.05	0.02	0.04	0.25	0.35	0.60	0.63	0.90	0.38	0.97	0.15	0.05	0.03	0.08	0.04	0.08
Pb	2.0	1.1	3.1	1.4	1.3	1.7	1.8	0.10	0.37	0.50	1.5	5.8	6.9	3.4	3.3	4.3	2.2	0.20	0.62	0.52	0.15	0.63	0.38
Th	66	37	107	46	45	58	62	3.5	11	15	41	196	194	108	86	127	57	5.5	21	15	4.5	19	11
U	926	435	931	557	590	468	669	192	25	64	190	345	331	234	196	207	343	93	55	80	135	29	103
Th/U	0.07	0.09	0.12	0.08	0.08	0.12	0.09	0.02	0.46	0.24	0.21	0.57	0.59	0.46	0.44	0.61	0.16	0.06	0.38	0.18	0.03	0.66	0.11
(Lu/Gd) _N	82.7	69.6	36.7	62.4	71.1	47.8	58.2	4.6	3.1	20.7	39.9	39.5	17.6	36.4	25.6	21.9	32.6	20.0	1.9	3.2	12.2	2.4	7.0
(Eu/Eu*) _N	0.58	0.56	0.59	0.54	0.53	0.55	0.53	0.75	0.72	0.88	0.43	0.28	0.21	0.21	0.15	0.26	0.14	0.77	0.67	0.79	0.67	0.48	0.73

bdl = below detection limit Eu*= (Gd+Sm)/2 The subscript "N" indicates values normalised to chondrite