LINKING MARTIAN BRECCIAS NORTH WEST AFRICA (NWA) 11220 & NORTH WEST AFRICA (NWA) 7034 TO THE MARTIAN METEORITE FAMILY; REVISITING THE MARTIAN NOMENCLATURE N. R. Stephen[1], [1]Plymouth Electron Microscopy Centre & School of Geography, Earth & Environmental Sciences, University of Plymouth, Drake Circus, Devon, PL4 8AA, UK (natasha.stephen@plymouth.ac.uk)

Introduction: The diverse surface of Mars holds the key to understanding its early differentiation and subsequent evolution, and is vital in our search for potentially habitable environments elsewhere in the Solar System. Martian meteorites are the only samples of the Martian surface currently available to science, and their age & origin have been widely studied [e.g. 1-6]. However, more recent finds have revealed a new class of brecciated Martian samples, e.g. North West Africa (NWA) 7034 and pairs, which do not fit into the existing classification scheme yet provide a more accurate match to previous rover data [7]. It has been hypothesized that these Martian breccias are either the result of volcanic activity on the Martian surface [7] or represent Martian regolith itself [8], unlike the other Martian meteorites representing true magmatic or volcanic rocks [9].

The composition of these new meteorites is largely comparable to the other Martian meteorites, however, there are highly variable textures described within each of the breccias that requires a new set of definitions to be applied. These new meteorites highlight the requirement to move towards a more inclusive nomenclature, which will allow for the incorporation of an increasingly diverse Martian collection.

Methods & Materials: Polished thin-sections (North West Africa 7034) and resin blocks (North West Africa 11220) were analyzed using a JEOL 7001F FEG-SEM within Plymouth Electron Microscopy Centre under standard operating conditions (20 kV), with an Oxford Instruments X-Max50 EDS detector. Data were standardized to international rock-forming mineral standards using Oxford Instruments AZtec™ software. Images were processed using Adobe Photoshop™ and the pixel-counting method [10]. A total of 183,488 pixels were counted within the clast (highlighted yellow, figure 2a).

Preliminary Results: Initial analyses of both breccia samples reveal multiple clast types and textures, with variable compositions also observed in [11]. The basaltic clasts vary in size but typically exhibit a subophitic texture with grains <50 µm. They are dominated by pyroxene (pigeonite) and feldspar (plagioclase), with associated Cl-apatite and Fe-Ti oxides. Very minor high-Ca pyroxene (augite) was observed in NWA 11220, with a CaO content higher than previously observed in basaltic Martian breccias [e.g. 8, 10], see table 2. In addition, a greater proportion of low-Ca pyroxene was observed within basaltic clasts in NWA 11220 than reported in NWA 7034 [7, 11]. Fine exsolution lamellae was observed in pigeonite within NWA 11220 and NWA 7034, but was not found in associated augite.

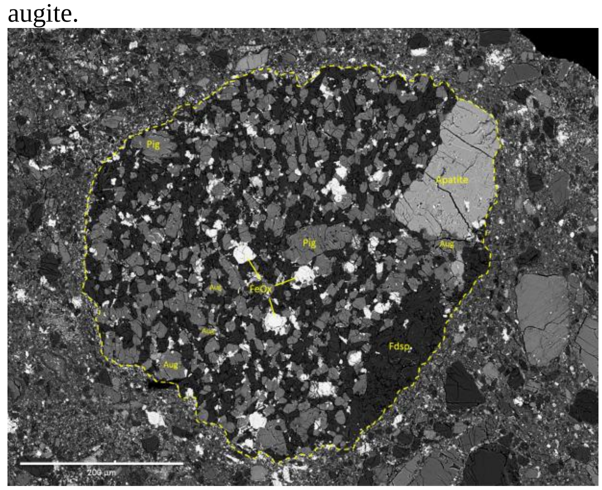

Figure 1: BSE image of basaltic clast within NWA 11220 showing granulitic texture of dominant low-Ca pyroxene (pigeonite) and feldspar (plagioclase), with Fe-Ti oxides and Cl-apatite.

Outside of the clasts, subhedral mineral fragments of pyroxene (both low and high-Ca pyroxene) were observed alongside Cl-apatite and Fe-Ti oxides. The fine-grained matrix is dominated by low-Ca pyroxene, with minor, anhedral plagioclase feldspar. Fragments of Cl-apatite were more abundant in NWA 11220 than previously reported, with fragments >150 µm observed (figure 1).

	Basaltic	Lherz.	Ol-phyric	Basaltic Clast	
	Shergotty[a]	NWA 2646[b]	DaG 476[c]	NWA 7034[d]	NWA 11220
Ol.	-	21.60	17.80	-	-
Pyx	67.00	65.00	55.30	30.00	36.49
Plag.	24.00	11.40	15.70	50.00	47.40
Opq	2.60	2.00	0.90	6.00	7.56
Phos.	2.00	-	1.50	5.00	8.56

Table 1: Example modal analysis of Shergottite types (a) Stöffler et al. 1986; (b) Bunch et al. 2005 (c) Wadhwa et al. 2001 (d) Santos et al. 2015 and NWA 11220 basaltic clast (this study).

Discussion: The modal analysis results of this study are in line with basaltic clasts in NWA 7034 described in [11], however, when comapared to the Martian Shergottites, the breccia's basalt clasts present with approximately double the feldspar and half the pyroxene content despite their *basaltic* nature, see table 1. The proportion of both opaque phases (Fe-Ti oxides) and phosphates (Cl-apatite) is greatly increased within the breccia clasts, compared to all Shergottite types. Despite the proportional differences, the composition of each phase identified within the basaltic clasts is comparable to the Martian Shergottite compositions (table 2).

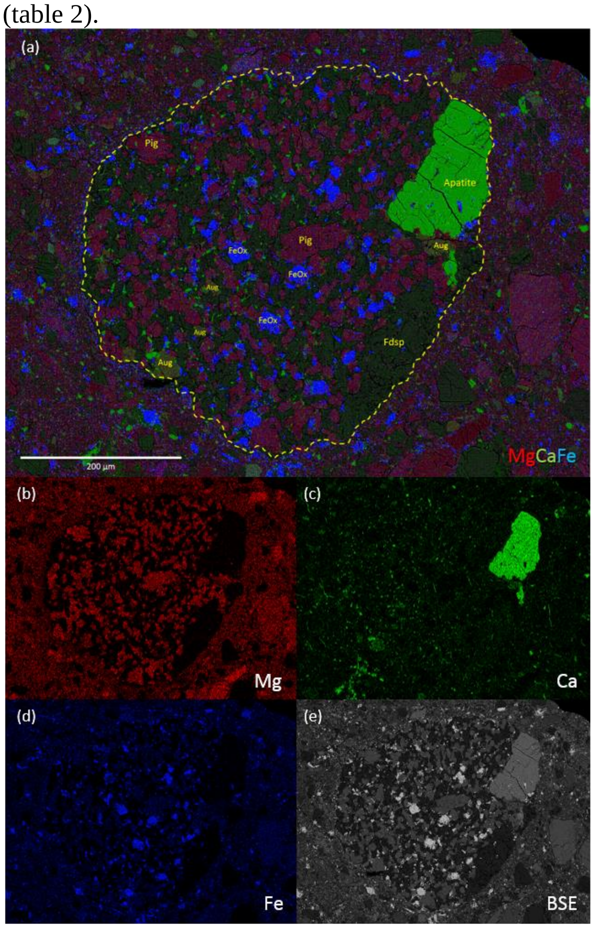

Figure 2: (a) Combined X-ray element map of basaltic clast within NWA 11220 **(b)** Mg element map **(c)** Ca element map, highlights the apatite fragment and Ca-rich pyroxenes **(d)** Fe element map highlights the Fe-Ti oxide distribution **(e)** BSE image.

Conclusion: The aim of this study is to compare the composition of the major constituent minerals seen in the new Martian breccias with those found in igneous Martian meteorites, and similarities between textures. Further analyses are required to determine average compositions of each phase within the varying clasts to allow such comparisons, however, further results will be presented at the meeting.

The complex and diverse nature of the brecciated Martian meteorites has necessitated the introduction of further terminology to describe the true nature of associated clasts [8, 11]. However, fewer comparable terms are used to describe the highly varied textures observed within the other members of the Martian meteorite family, and the proportions of each phase within the breccias is not directly comparable to the most similar of Martians, the Shergottites.

	MgO	Al_2O_3	SiO_2	CaO	Fe_2O_3	Total
1	21.76	1.30	52.86	2.30	12.77	100.00
2	22.29		52.15	3.54	22.02	100.00
3	23.03		52.96	1.96	22.05	100.00
4	21.07		52.54	4.75	21.64	100.00
5	19.65		54.09	4.21	22.05	100.00
6	20.99	2.66	52.29	5.68	18.38	100.00
7	14.03	1.86	52.51	18.79	12.81	100.00
8	15.06		53.08	19.17	12.69	100.00
9	15.91		52.17	17.41	14.51	100.00

Table 2: Pyroxene compositions within a basaltic clast observed in NWA 11220 (figure 1) determined by standardized SEM-EDS. Grains 1-6 are low-Ca pyroxene (pigeonite) whilst grains 7-9 are high-Ca pyroxene (augite).

It is perhaps time that we considered the extension of current nomenclature to truly represent the textural and compositional variation observed within the ever-expanding suite of Martian meteorites, to readdress the Shergottite variation and more closely link the new Martian breccias.

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